



# micropaleontology

volume 2  
number 2

april 1956

PUBLISHED BY:

*Department of Micropaleontology*  
*American Museum of Natural History*  
*Central Park West at Seventy-Ninth Street*  
*New York 24, New York*

# micropaleontology

## articles

Upper Cretaceous and Lower Tertiary foraminifera from northern Sinai, Egypt	RUSHDI SAID AND ABBAS KENAWY	105
South American Paleozoic sporomorphae without haptotypic structures	FRIEDRICH WILHELM SOMMER	175
Transatlantic correlation of the Oligo-Miocene by means of foraminifera	C. W. DROOGER	183

## notes and comment

" <i>Nodosinella</i> Brady, 1876, and associated Upper Palaeozoic genera"—A comment	JAMES E. CONKIN	193
---	-----------------	-----

## news reports

Brazil	FREDERICO W. LANGE	194
Germany	H. HILTERMANN	194
India	S. R. N. RAO	196
North Africa	MARCEL REY	198
United States—West Coast	HANS E. THALMANN	199

*The subscription price of this quarterly is \$8.00 per year. Single copies are \$2.50 each.*

**ABSTRACT:** This paper describes and illustrates some 275 species of foraminifera from the Upper Cretaceous and Lower Tertiary strata of two sections in the northern part of the Sinai Peninsula, Egypt. An attempt is also made to zone and correlate the strata of the two sections and to explain the peculiar temporal and spatial distribution of species in them. It is believed to have been caused by the type of basin in which the sedimentation of these two successions took place. The tectonic history of the basin is discussed, and its influence on the distribution of species is suggested.

## **Upper Cretaceous and Lower Tertiary foraminifera from northern Sinai, Egypt**

**RUSHDI SAID AND ABBAS KENAWY**

*Cairo University  
Cairo, Egypt*

### **INTRODUCTION**

The Upper Cretaceous—Lower Tertiary succession in Egypt is represented by a variety of sediments that are differently interrelated both in space and in time. Great lateral variation, thinning out, and wedging of the sediments occur; highly angular unconformities, minor disconformities, and continuous sedimentation have all been observed in areas that are geographically near one another.

For practical purposes, this Upper Cretaceous—Lower Tertiary sequence is divisible into three mappable rock units that are easily recognizable in the field and of wide lateral extent. These rock units are (from base to top): The Chalk, which is a series of bedded, fine-grained limestones; this unit is overlain by a sequence of shales and marls with intercalations of chalk beds, which is known in the literature as the Esna shales; the latter is followed by a third formation, a massive limestone. These formations are dated by field geologists as Campanian and/or Maestrichtian for the Chalk, Danian and/or Paleocene for the Esna shale, and Lower Eocene for the upper limestone formation. The age assigned depends upon the practice of the particular organization to which the geologist belongs. The thickness of these rock units varies greatly from place to place, although the Esna shale is thicker and more sandy toward the south of Egypt. In the north, however, a puzzling picture presents itself, for extremely thick sequences are found adjoining sections in which the Esna formation is very thin or is even entirely absent.

It is obvious that, with such a picture, controversy regarding the nature of the contact between the Cretaceous and the Eocene has existed. Authors whose experience has come from areas where there are unconformable relations between the two systems have generalized from their previous experience and have maintained that there was a break in sedimentation (Barron, 1907; Boussac, 1913; Cuvillier, 1930 (but see also the same author, 1949); Ball, 1939). On the other hand, those who have observed no unconformities between the two systems have generalized from their previous ideas and have concluded that there was continuous sedimentation between the two systems, sometimes with the reservation that exceptions exist (Zittel, 1883; Beadnell, 1927; Picard, 1943; Tromp, 1942 and 1949; Faris, 1947, etc.).

In a recent brilliant paper, Shukri (1954), on the basis of a study of numerous measured sections and geophysical data, has suggested an alternative interpretation for the existence of these different interrelations. He visualizes Egypt as an area with elongated ridges rising from the bottom of the Cretaceous sea. These ridges ran in a northeast-southwest direction, extending across Egypt in alignment with the Syrian "arcing" system. In later time, these ridges intermittently submerged and emerged because of pulsating lateral compressional movements that continued until late Oligocene time.

Along these ridges, unconformities occur within the Cretaceous and the Eocene and between the two sys-

## SAID AND KENAWY

tems. The basins separating these ridges were sites of continuous sedimentation. The degree of unconformity was governed by two factors: The amount of uplift, as a result of which localities that represented big structural highs show the most marked unconformities (e.g., Moghara and Shabrawet); and the position relative to the highs (crest or flank). The effect of position on the extent of unconformity is well exemplified in the Abu Roawash structure, where the Upper Eocene directly overlies the Senonian in the conspicuous northern Abu Roawash anticline, the upper Middle Eocene overlies the Senonian in the less pronounced Giran el-Ful anticline, and the lower Middle Eocene overlies the upper Senonian in the intervening syncline south of Sudr el-Khamis. The fact that the stratigraphic position of the unconformities is variable (within the Cretaceous, between the Cretaceous and the Eocene, and within the Eocene) is explainable by the fact that the orogenic movement of the Syrian arcs was intermittent from its beginning, which was at least as early as the Turonian.

It is with this picture in mind that we started this investigation. We wanted to study the influence of the bottom topography of the late Cretaceous sea on the vertical and lateral distribution of foraminifera. We have therefore studied two sequences that are believed to have been deposited under different environmental conditions. The Nekhl section lay in the heart of a trough in the late Cretaceous sea, while the Giddi area lay only a few kilometers to the northwest on the flank of one of the main structural highs of that time. It is obvious that, on the whole, thicker sediments will be found in the trough section, and that these sediments will be more calcareous in nature and with a lower clastic ratio.

### ACKNOWLEDGMENTS

The authors wish to express their gratitude to Dr. A. R. Loeblich, Jr., of the U. S. National Museum, for critically reading the manuscript, for clarifying many taxonomic problems, and for his great help in preparing this paper in its final form. Thanks are also due to Professor N. M. Shukri, for giving us full use of his data and material from Nekhl, and to the management of Anglo-Egyptian Oilfields Ltd., for permitting us the use of their section and samples from Giddi.

### MATERIAL AND METHOD OF STUDY

The material upon which this study is based came from two sections in northern Sinai, Egypt.

### Nekhl

Lat.  $29^{\circ}50' N.$ , long.  $33^{\circ}34' E.$  This section was measured and sampled by Professor N. M. Shukri. The columnar section constructed from the data appears in text-figure 1.

Rock unit	Lithology	Thickness in meters	Cumulative thickness	Sample no.
Safra beds	Limestone with flint	14.8	270.4	
Esna shale (55 meters)	Grey shale	7	256	11
	Brown limestone with flint	3	249	
	Shaly limestone	1	248	9
	Grey calcareous shale	20	245	
	Shaly limestone	4	225	8
	Shale	20	221	7
Chalk (141 meters)	Chalky limestone	2	201	
	Shaly limestone	1	199	6
	White hard chalk	10	198	
	White fine-grained soft chalk	120	188	21
	Chalky limestone	5	68	
	Chalky limestone	2	63	
Santonian (60 meters)	Sandy limestone	1	61	
	Glauconitic sandy limestone interbedded with flint bands	60	60	

local unconformity

### Giddi

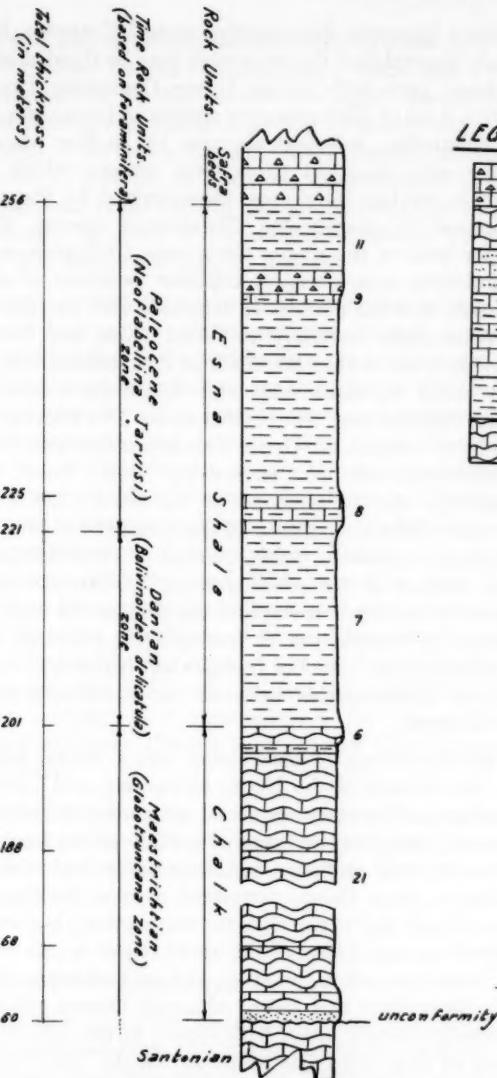
Lat.  $30^{\circ}09' N.$ , long.  $33^{\circ}15' E.$  This section was measured and sampled by Anglo-Egyptian Oilfields Ltd. The columnar section constructed from their data is given in text-figure 2.

Rock unit	Lithology	Thickness in meters	Cumulative thickness	Sample no.
	Limestone, somewhat marly			859-867
Esna shale	Limestone with flint	3	32%	
	Shaly limestone	13 $\frac{1}{2}$	29%	846-857
	Limestone	$\frac{1}{2}$	16 $\frac{1}{2}$	845
	Grey shale	7 $\frac{1}{2}$	15%	837-844
	Limestone	$\frac{1}{2}$	7 $\frac{1}{2}$	836
	Grey shale	6 $\frac{1}{2}$	6%	833-835

### Chalk

We have made a slight change in the Anglo-Egyptian Oilfields log so as to include in the Esna shale the

## FORAMINIFERA FROM SINAI



TEXT-FIGURE 1

Columnar section showing the major subdivisions of the Nekhl section, northern Sinai, Egypt.

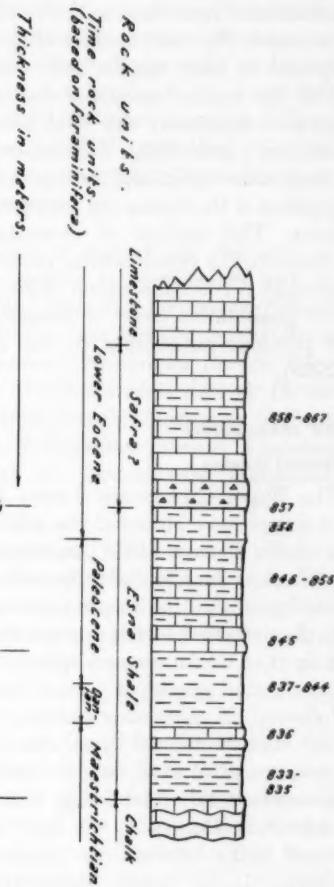
shaly limestone that lies below the "limestone with flint." This was done in order to make the two sections comparable, and to make the presentation of the Nekhl and Giddi logs uniform with regard to the units recognized.

### Method of study

One hundred grams of each sample was mortared and treated in the following manner: The shaly samples

### LEGEND

Limestone with flint
Chalky limestone
Sandy limestone
Shaly limestone
Limestone
Shale
Chalk



Columnar section showing the major subdivisions of the Giddi section, northern Sinai, Egypt.

were heated on a gas plate to drive out the interstitial moisture, and then they were immersed in kerosene while still hot and allowed to remain there for about six hours (Crowley, 1952). The kerosene was then decanted and water was added. The sample was then found to disintegrate easily and was ready to be wet-sieved.

The harder limestone samples were placed in bottles together with small iron cylinders one centimeter in

diameter and about three centimeters in length, covered with rubber tubing. The samples and cylinders were then shaken in a mechanical shaker for about ten hours (Brotzen, 1950). Each sample was then wet-sieved.

Each disintegrated sample was examined and all foraminiferal specimens in the residue were picked and mounted. The total number of specimens of benthonic species in each sample was counted and divided by 100, the original weight of the sample. The figure so derived represents the total benthonic foraminiferal number (Said, 1950). The numbers that appear in the distribution table and histograms showing the composition of the faunas are the number of specimens per gram. This method of presentation is believed to eliminate the discrepancies present in the percentage method. A fuller discussion of the problems involved in the quantitative study of foraminifera is presented in a previous publication by the senior author (Said, 1950).

#### THE FORAMINIFERA

##### Previous literature

The Upper Cretaceous—Lower Tertiary foraminifera of Egypt have attracted the attention of a number of workers. Henson (1938) summarized the distribution of foraminifera in Palestine and adjoining countries, and noted that the Upper Cretaceous is distinctive. It is characterized by the appearance of index forms and a flood of *Globotruncana* species, as well as large and ornamented species of *Gümbelina*. This assemblage is followed, in continuous sections, by another sequence that is characterized by an abundance of *Globigerina* species and of sharp-keeled *Globorotalia* species. He interpreted this assemblage, which extends from the uppermost Danian to the early Eocene, as a transitional fauna between the Upper Cretaceous and the Eocene. In the Eocene, the sharp-keeled *Globorotalia* species give way to the more rounded species of *Globorotalia* and the large, thick-shelled, coarsely perforate, and spiny species of *Globigerina*. He noticed, however, that the transitional fauna was not typically developed at the contact of the Cretaceous and Eocene, even when there was no evidence of a break in deposition between the two systems. He therefore concluded that an imperceptible gap must exist between them.

Nakkady (1950, 1951) carefully studied the foraminiferal content of six widely separated Upper Cretaceous to Lower Tertiary successions, in order to determine the age of the controversial Esna shale formation that lies between the Cretaceous Chalk and the overlying

Eocene limestone. He recorded some 167 species. His study showed that the succession may be divided into a lower part, with typical Upper Cretaceous forms, with a flood of *Globotruncana* species and large species of *Gümbelina*, followed abruptly by another assemblage with abundant *Globigerina* species, which in turn is overlain by a zone characterized by the appearance of sharp-keeled *Globorotalia* species. The upper limit of the Upper Cretaceous *Globotruncana-Gümbelina* zone occupies different positions in the sections that he studied. It coincides with the Chalk—Esna shale boundary in Gebel Duwi and Wadi Danili; it lies within the shale at Abu Durba; and it lies below the Esna shale and within the Chalk in Wadi Mellaha and Um el-Ghanayem. The intermediate layer between the Upper Cretaceous fauna and the *Globorotalia* zone was termed the "Buffer Zone" by Nakkady, and, as is shown in his chart (1951), it occupies different portions of the sections and attains different thicknesses, being thinnest at Wadi Mellaha and thickest at Um el-Ghanayem. No attempt was made by Nakkady to explain the reasons for such a pattern of distribution of foraminifera, although he agrees with the school of thought that believes in continuous sedimentation between the Cretaceous and the Eocene.

A similar pattern of distribution and a similar basis for the division of the Upper Cretaceous and Lower Tertiary sedimentary sequence were also found by Osman (1954), on the basis of a study of the foraminifera of two sections, the Raha scarp and Gebel Qabeliat, Sinai. Osman attempted to zone the Cretaceous Chalk and to correlate the two sections, but with limited success. Many of the zones found in one section were missing in the other, and no explanation for this discrepancy was given. Although Osman echoed Nakkady's earlier views with regard to the abandonment of such lithologic terms as "Chalk" and "Esna shale," he correlated the practically unfossiliferous limestone series of the Qabeliat section with the Sudr section on lithologic grounds.

LeRoy (1953) studied the foraminiferal content of the Maqfi section (Farafra Oasis, Western Desert, Egypt) and recorded nineteen Upper Cretaceous and 112 "Lower Tertiary" species of foraminifera. He divided the section according to its foraminiferal content into a lower Maestrichtian unit "A," and four Lower Tertiary units (IV, III, II, and I). The upper limit of the Maestrichtian unit is characterized by an abundance of *Globotruncana* and *Gümbelina* within the Chalk, while the four Tertiary units comprise the upper part of the Chalk and the Esna shale. Unit IV is characterized by the absence of *Globorotalia* and *Gümbelina*.

## FORAMINIFERA FROM SINAI

species and by the appearance of *Globorotalia velascoensis* (basal Eocene or Paleocene?), while unit III is characterized by the presence of small *Nummulites* and *Operculina*, which, according to LeRoy, mark the advent of the Lower Eocene. LeRoy did not, therefore, record a "buffer zone" between the decidedly Upper Cretaceous fauna and the *Globorotalia*-bearing strata, although he noted a disconformity between his unit "A" and the Lower Tertiary unit IV.

Tromp (1952) reviewed the micropaleontology of Egypt and, using his quantitative generic method, concluded that in the Middle East the uppermost Cretaceous and Lower Eocene are transitional. The Cretaceous possesses a rich fauna with abundant species of *Globotruncana* and several other genera, whereas species of *Globorotalia*, mostly of the sharp-keeled type, are very abundant in the basal Eocene. The basal Eocene is also marked by a flood of *Globigerina* and the appearance of such typical Tertiary genera as *Uvigerina*, *Orbulina*, and *Globigerinoides*, which are missing from upper Senonian faunas even in samples that have an abundance of forms. These results were corroborated by the work of one of Tromp's students (Omara, 1951 MS.), who studied the quantitative generic distribution of foraminifera in the Upper Cretaceous to Lower Tertiary succession of Gebel Nezzet, Sinai.

Faris (1947) mentions the occurrence of some species of foraminifera in his study of the Cretaceous-Eocene contact in the Tramsa-Tukh area (Nile Valley, Quena, Egypt).

### Distribution in the sections studied

Some 275 species of foraminifera were distinguished and recorded from the Nekhl and Giddi sections. In the following paragraphs, the distribution of these species in the two sections is given.

**Nekhl:** Six samples were studied, of which nos. 21 and 6 come from the Chalk series, and nos. 7, 8, 9, and 11 come from the so-called Esna shale. No. 7 is the lowest of the latter and no. 11 the highest, coming from near the overlying limestone.

The Chalk samples, nos. 21 and 6, contain a characteristic fauna that is quite different from that of the higher samples. The *Globotruncana* species are restricted to these two samples, with a flood of the single-keeled type in the upper Chalk sample, no. 6. These species, together with the associated large species of *Gümbelina*, are completely absent from the overlying Esna shale samples. Other distinctive and character-

istic species of this zone are the following: *Tritaxia barakai*; *Clavulinoides asper*; *Heterostomella austinana*; *Hagenowella gibbosa*; *Dentalina basiplanata*; *Lagena apiculata*; *Lagena sulcata*; *Rectoglandulina pygmaea*; *Pyrulinoides acuminatus*; *Planoglobulina acervulinoides*; *Ventilabrella eggeri*; *Ventilabrella eggeri glabrata*; *Bolivinoides draco draco*; *Bolivinoides draco dorreeni*; *Bolivinoides curtus*; *Eouvigerina aegyptiaca*; *Buliminella laevis*; *Buliminella cushmani*; *Bulimina kickapooensis*; *Lacosteina cf. gouskovi*; *Bolivina decurrens parallela*; *Bolivina incrassata*; *Loxostomum tegulatum*; *Gyroidina girardana*; *Gyroidinoides nitidus*; *Stensiöna americana*; *Stensiöna excolata*; *Globorotalites conicus*.

Other species that seem to characterize this unit, although they do not appear in comparable beds in Giddi, are the following: *Involutina tenuissima*; *Glomospira gordialis*; *Pseudoclavulina pseudoarenata*; *Clavulinoides trilatera concavus*; *Karreriella danica*; *Marginulinopsis comma*; *Marginulinopsis deserti*; *Dentalina catenula*; *Dentalina ghorabi*; *Nodosaria limbata*; *Vaginulina misrensis*; *Lenticulina rotulata*; *Virgulina navarroana*; *Virgulina* sp.; *Loxostomum tegulatum*; *Siphogenerina* sp.

The lower Chalk sample, no. 21, has strong affinities with sample no. 6, although it is different in having double-keeled *Globotruncana* species, in having *Bolivinoides draco miliaris* but not *B. draco draco*, and in having a flood of *Virgulina navarroana*, V. sp., and *Buliminella cushmani*.

This assemblage from the Chalk samples is quite different from that of the overlying Esna shale samples. The Maestrichtian aspect of the fauna listed above is obvious. The presence of the single-keeled *Globotruncana stuarti* and *G. caliciformis* points to a Maestrichtian age, as found by Bolli (1951) in Trinidad and by Marie (1941, 1949). Marie (1949), on the basis of a study of sections in North Africa, divided the Upper Cretaceous Aturian stage into several zones, according to their foraminiferal content. Our assemblage can be correlated with Marie's Aturian IV, of upper Maestrichtian age. Many of the forms recorded in this part of the section correspond well with many of those known from the Navarro group of the United States Gulf Coast area (Cushman, 1946; Frizzell, 1954). The occurrence of *Bolivinoides draco draco* and *B. draco miliaris* in this unit indicates its affinity with the Maestrichtian of northwestern Germany (Hiltermann and Koch, 1950) and of Israel (Reiss, 1954). The same age is also suggested by the associated *Neoflabellina* species (Hiltermann, 1952).

The lower Esna shale unit, 20 meters in thickness (sample no. 7), is characterized by the absence of *Globotruncana* species and by the presence of a flood of *Globigerina* species, together with certain characteristic species such as: *Bolivinoides delicatulus*, *Neoflabellina suturalis*, *Bolivinita bandyi*, *Eouvigerina hofkeri*, *Stilostomella paleocenica*, and *Höglundina esnaensis*. Many other species characterize only the Nekhl Danian, and do not occur in Giddi: *Pseudoclavulina globulifera*, *Clavulinoides* cf. *cubensis*, *Pseudogaudryinella compacta*, *Nodosaria affinis*, *Vaginulina taylorana*, *Enantiomorphina lemoinei conica*, *Enantiomorphina lemoinei inflata*, and *Enantiovaginulina recta*. No *Truncorotalia* species have been recorded from this zone.

This assemblage coincides with Nakkady's "buffer zone." It seems to be absent from the faunal successions described by LeRoy, and seems also to have escaped the attention of Tromp. The appearance of *Bolivinoides delicatula* indicates a Danian age, as recently suggested by Reiss (1954), while the presence of *Pseudoclavulina globulifera* and *Pseudogaudryinella compacta* may indicate the correlation of this bed with the Dano-Montian of Algeria (ten Dam and Sigal, 1950). The complete absence of *Globorotalia* and *Truncorotalia* species from this bed suggests a strong affinity with the Danian of Aquitaine (Cuvillier and Szakall, 1948).

On the other hand, this fauna shows relations that have led other authors to consider it transitional. The presence of the typically Eocene *Vulvulina colei* is peculiar, and it must be concluded that this genus existed in very late Cretaceous time. The appearance of typical *Enantiomorphina* and *Enantiovaginulina* in this unit also needs explanation, as these forms have been recorded by Marie (1941) from the Mucronata zone of the Senonian (in part Maestrichtian). It may be, therefore, that this unit might better be assigned a noncommittal age such as Dano-Montian, as has been done by North African geologists (e.g., Drooger, 1952), or Dano-Paleocene, as has been done in Israel (Reiss, 1954).

Samples no. 8, 9 and 11, which also come from the Esna shale formation, can be treated as a unit with regard to their foraminiferal content. These samples are characterized by the appearance of various species of *Truncorotalia* and *Globorotalia*, together with such distinctive species as: *Robulus midwayensis carinatus*, *Frondicularia* cf. *clarki*, *Stilostomella alexanderi alexanderi*, *Charltonina toddae*, and *Neoflabellina jarvisi*. The following species characterize the Nekhl section only: *Spirolectammina henryi*, *Dorothia pontoni*,

*Nodosaria paupercula*, *Nodosaria zippei*, *Rectoglandulina bulla*, *Glandulina laevigata*, *Bolivinopsis clotho*, *Buliminella carseyae*, *Bulimina arkadelphiana midwayensis*, *Rectuvigerina advena*, *Nodosarella subnodososa*, and *Valvulineria scrobiculata*.

This assemblage shows great affinity with the fauna of the Velasco shale of Mexico and the Lizards Springs formation of Trinidad (Cushman and Renz, 1946), whose age has been in dispute for some time. Cushman and Renz (1946), Cushman (1947), and Renz (1951) believe that these formations belong to the Upper Cretaceous, and Cushman (1946) included their fauna in his well-known monograph on the Upper Cretaceous. Grimsdale (1947), however, and later Bolli (1951), considered that these formations belong to the Paleocene, a belief that is now shared by many authorities working in Trinidad.

This part of the section is therefore believed to be of Paleocene age, a view that is further substantiated by the presence of a few typically Paleocene American Gulf Coast forms (Cushman, 1951) and northern European forms (Brotzen, 1948), and by the sudden dominance of such forms as *Truncorotalia* and *Globorotalia* (Glaessner, 1945; Reiss, 1954).

From the discussion above, it appears probable that the Upper Cretaceous—Lower Tertiary sequence of Nekhl can be zoned on the basis of foraminifera. The lowermost zone (Maestrichtian) is marked by a fauna that is comparable to that which occurs in the Maestrichtian in many parts of the world. This zone can be placed in the stratigraphic column with little trouble, as it includes excellent short-lived species that seem to have wide geographic distribution. The majority of the species are known from the Tampico Embayment and the American Gulf Coast area (Cushman, 1946), together with a few forms from northern Europe (Franke, 1928; Reuss, 1860; Marie, 1941). The upper limit of this zone is well marked and coincides with the lithologic change in the succession.

The Esna shale of the Nekhl section is divided into two units that succeed each other with no apparent hiatus or lithologic change. The lower unit, here assigned to the Danian, is characterized by an abundance of representatives of the family Globigerinidae and the presence of *Bolivinoides delicatula*. No *Truncorotalia* species have been found in this unit. The upper unit is marked by a flood of *Truncorotalia* species, together with representatives of the family Globigerinidae. This unit is characterized by the absence of species of *Bolivinoides* and the appearance of *Neoflabellina jarvisi*. It belongs most probably to the Paleocene.

## FORAMINIFERA FROM SINAI

*Giddi*: Thirty samples were studied from this section, of which twenty-one came from the Esna shale, the lower part of the section, and nine came from the overlying Eocene limestone.

The succession studied can be divided into four units. The lowest unit, comprising the lower Esna shale samples no. 833-835, contains typical upper Maestrichtian forms such as *Globotruncana stuarti*, *Globotruncana caliciformis*, *Bolivina incrassata*, *Globorotalites conicus*, *Stensiöina americana*, *Stensiöina excolata*, *Buliminella laevis*, *Buliminella cushmani*, *Planoglobulina acervulinoides*, *Ventilabrella eggeri*, etc.

This assemblage can be correlated with that of the Nekhl Chalk (samples no. 21 and 6). It assumes, however, a different aspect here, as it does not include as many representatives of the arenaceous foraminifera or of the Lagenidae.

This unit is followed by another, comprising the Esna shale samples no. 837-840. This thin unit is characterized by the absence of *Globotruncana* and of large species of *Gümbelina*, as well as of other characteristic Maestrichtian forms, and by the presence of *Bolivinoides delicatus*, *Eouvigerina hofkeri*, *Spiroplectammina dentata*, and *Involutina cretacea*, together with others that occur only in Giddi: *Clavulinoides asper whitei*, *Robulus turbinatus*, *Saracenaria saratogana*, *Cibicides cf. beaumontianus*, *Eoguttulina anglica*, *Rectogümbelina cretacea*, *Rectogümbelina longa*, *Orthonomorpha rohri*, *Ellipsoglandulina exponens*, *Gyroidina planulata*, *Gyroidina reussi*, and *Neorotalia* sp.

Although it is obvious from this assemblage that this unit can be correlated with the Danian lower Esna shale unit of Nekhl, the aspect of the faunas on the whole is quite different in the two sections. No *Enantiavaginulina* or *Enantiomorphina* have been encountered in Giddi. Representatives of the families Globigerinidae and Lagenidae, as well as of the arenaceous families, are much rarer in numbers of individuals and in numbers of species. The reasons for this difference in the aspect of the faunas between such contemporaneous and geographically neighbouring localities will be discussed in the following section.

This unit is followed by another, comprising samples no. 842-855, from the upper part of the Esna shale. The latter unit is characterized by an abundance of representatives of the family Globigerinidae and by the presence of *Neoflabellina jarvisi*, *Stilostomella alexanderi alexanderi*, *Charltonina toddae*, *Clavulinoides trilatera*, *Marssonella oxycona trinitatensis*, and *Guttulina trigonula*.

This assemblage shows strong affinities with the Paleocene assemblage of the Nekhl section. It must be emphasized, however, that this assemblage differs materially from that of Nekhl in the absence of certain characteristic forms and in the retardation of the appearance of the oft-quoted fossil *Truncorotalia velascoensis*. This species appears only in the higher part of the section, at the level of sample no. 851.

This unit is composed of shale in the lower part and marly limestone in the upper part. The change of lithology in this unit corresponds with a change in the foraminiferal fauna. There is a sudden flood of arenaceous forms and of representatives of the family Lagenidae in the lower limestone samples. Whether this change is of chronologic significance or is merely a reflection of changing ecologic conditions is a matter that will be discussed later.

The lowest part of this unit (sample no. 842) contains *Bolivinoides curtus*, a species that appears in the upper Danian and lower Paleocene of Israel. This species has not been recorded in lower samples, and may be considered an index to the Egyptian lower Paleocene.

The topmost samples of the section studied (samples no. 859-870), or the part that lies above the "limestone with flint," contains an assemblage characterized by a flood of *Truncorotalia spinulosa* and *Truncorotalia velascoensis*, together with *Gaudryina soldadoensis*, *Clavulinoides guayabalensis*, *Dorothia sinaensis*, *Marginulina curvatura* and *Cibicides farafrensis*.

This unit is comparable with LeRoy's unit II (Lower Eocene) and includes many species recorded from that horizon in Mexico and Trinidad. This unit is not represented in the part of the succession studied in Nekhl.

### Remarks on distribution

The distribution of these foraminifera both in space and in time shows many interesting peculiarities. The upper limit of the faunistic unit which is here assigned to the Maestrichtian, and which contains typical Upper Cretaceous forms together with numerous species of *Globotruncana*, coincides with the Chalk-shale boundary in the Nekhl section but lies within the Esna shale in the Giddi area. Similar findings have been reported by Nakkady (1950, 1951). In a study of six widely separated sections of the Esna shale of Egypt, Nakkady found that at some localities the *Globotruncana-Gümbelina* zone cuts into the Esna shale, while at others it coincides with the change in lithology between the Chalk and the Esna shale or

even cuts into the Chalk. Osman (1954), in a study of two sections on the Sinai side of the Gulf of Suez, found that the *Globotruncana-Gümbelina* zone cuts into the Esna shale.

Another interesting peculiarity in the distribution of these foraminifera concerns the appearance of the so-called "*Globorotalia*" zone in the two sections studied. Whilst this zone cuts into the Esna shale and appears only a few feet above the top of the Maestrichtian in Nekhl, it appears at a much higher level (and also later in time, as indicated by the associated foraminifera) in the Giddi section. The chart given by Nakkady (1951), based on a study of similar sections, shows that his "buffer zone," which lies between the upper limit of the *Globotruncana-Gümbelina* zone and the first appearance of *Globorotalia* (our Danian in part), assumes different thicknesses at different localities, some of which are very near each other.

The distribution of the foraminifera in space is also worth emphasizing. Although there are many forms that are common to both of the sections studied, there are many others that appear only in one section and not in the other. Osman (1954) found a similar pattern of distribution in the two sections he studied, and his attempt to correlate them met with only limited success.

Although this pattern of distribution has been known for some time, no explanation has hitherto been offered for these discrepancies in the temporal and spatial distribution of species. Why is it that timelines, as indicated by the upper limit of the *Globotruncana* zone, do not occupy the same position in the different sections? Why is it that Nakkady's "buffer zone" assumes different thicknesses in localities so near each other? Why is it that such great differences in the composition of the faunas exist in contemporaneous beds of such nearby sections? It is the opinion of the authors that this pattern of distribution can be explained by taking into consideration the tectonic history of Egypt during and at the close of Cretaceous time, and the type of sedimentation that followed this new configuration of the sea-bottom.

Text-figure 3 gives the composition of the foraminiferal faunas of the sections studied, arranged chronologically and according to families. It is evident that the total foraminiferal numbers of the families *Lagenidae* and *Ellipsoidinidae* are always greater in Nekhl than in Giddi. This figure also shows that the contemporaneous portions of the two sections studied differ in the composition of their foraminiferal faunas.

#### SEDIMENTARY HISTORY, TECTONICS AND FORAMINIFERA

##### Reconstruction of the basin of deposition

Mention has already been made of the fact that Egypt was subjected, at least as early as Cretaceous time, to lateral compressional movements that gave rise to a number of northeast-southwest-trending "arcs" running parallel to each other across the country. This configuration of the sea-bottom not only affected the stratigraphic relationships of the rocks of the late Cretaceous and Lower Tertiary, as was previously mentioned, but it also seems to have affected the distribution of foraminifera in space.

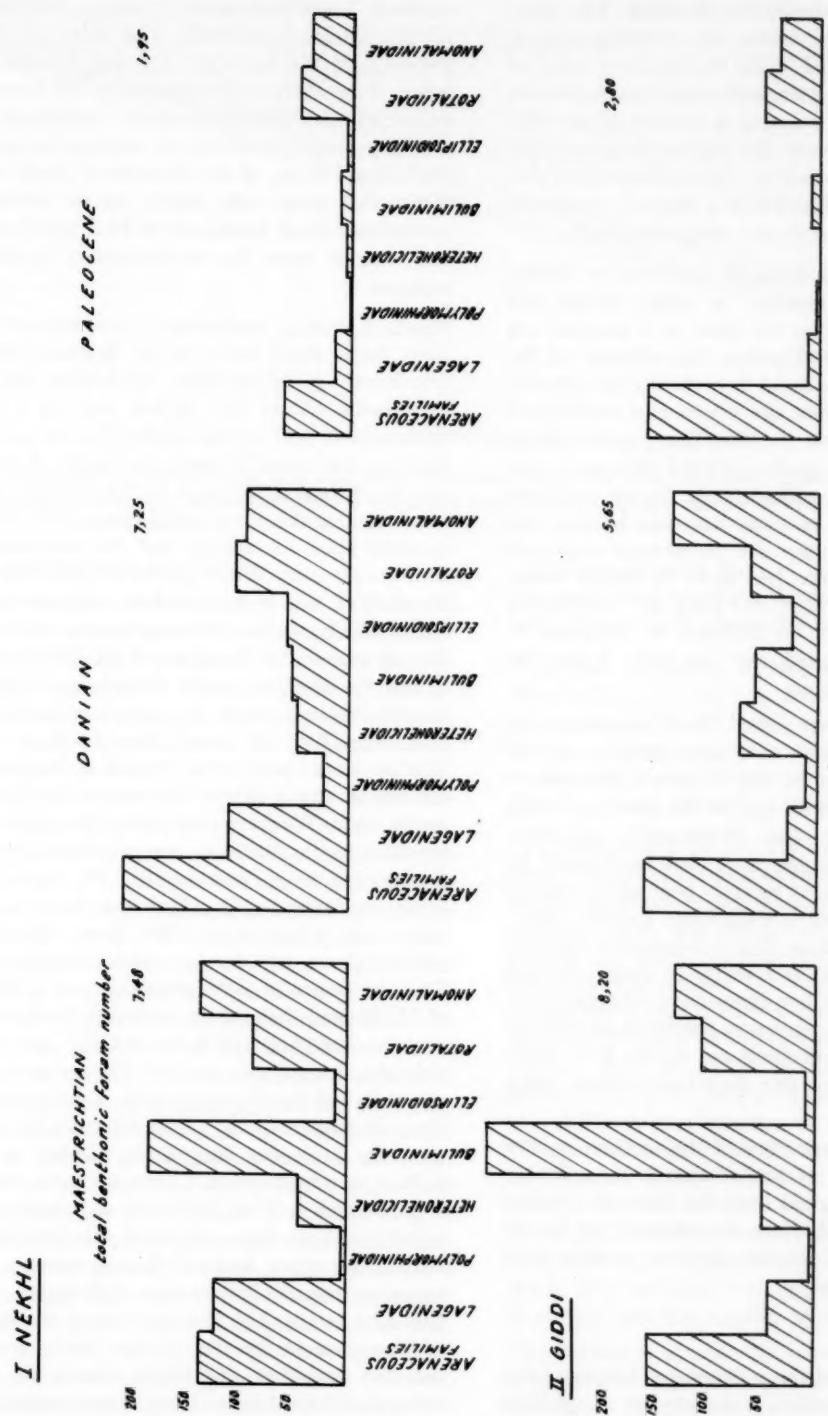
The sections studied in this work are situated at two localities that represent different environmental conditions in the Upper Cretaceous—Lower Tertiary sea. The Nekhl section lay in the heart of a trough that was probably established early in Maestrichtian time. The Santonian-Campanian unconformity in this section indicates an even earlier small arching, which must have been levelled down, probably before late Campanian time. Field evidence conforms with gravity measurements in indicating that the Upper Cretaceous shows no unconformity of any sort with the exposed Eocene.

The Giddi section lay on the southern flank of the Giddi dome, which forms part of the Halal line of uplifts (Shukri, 1954, p. 78). Farther north, at G. Ugret el Aiyada (lat. 30°11' N.; long. 33°13' E.), a section that shows unconformity between the upper Senonian and the Paleocene is assumed to have lain on the crest of the Giddi structure (Shukri, 1954).

Sedimentation took place upon this "arch and trough" configuration. Text-figure 4 is a conventionalized diagram to show this type of sedimentary basin; it was constructed on the basis of the three sections at hand: the Nekhl section in the trough, the Giddi section on the flank, and the Ugret el Aiyada section at the crest. It is not in any sense a complete stratigraphic diagram, as the relative thickness and horizontal extent of each formation are not known in detail. Based in part on the data from these three sections and in part on inference, it is intended to illustrate the process of sedimentation, rather than actual conditions. In such a type of basin, where the sea level has varied considerably during the sedimentational history, as shown by changes in lithology in the sections studied, onlap and offlap relationships are common.

Each advance or retreat of the sea produces conditions of onlap or offlap, which show clearly in the stratigraphic record. Under the simplest conditions of rising sea level, progressive overlap, or onlap, means that the

# FORAMINIFERA FROM SINAI



TEXT-FIGURE 3

Histograms showing the composition of the faunas of the time-rock subdivisions of the two sections studied.

younger deposits overlap the older in a shoreward (in our particular case ridgeward) direction. The near-shore facies are sandy, while the contemporaneous offshore facies deposited while the sea level stood at the same position are muds, with calcareous sediments deposited still farther seaward if conditions are suitable. In a vertical section, this results in shales overlying sandstones, followed in turn by limestones that overlie the shales. It represents a time of continuous accumulation of sediments in a deepening sea.

Conversely, under the simplest conditions of falling sea level, regressive overlap, or offlap, means that younger deposits overlap the older in a seaward (in our case troughward) direction. An advance of the shoreline may also be caused theoretically by a greater supply of sediment than the waves can redistribute and remove. At or near the shoreline, coarse clastics are deposited, which grade seaward into muds and finally into calcareous sediments. As the sea continues to retreat, the muds of what has now become the shoal-water zone overlap the calcareous sediments that had previously been laid down in deeper water. The surface of the ridge and shelf are undergoing erosion, with reduction in thickness or complete removal of strata deposited near the shore during the previous onlap conditions.

These are the simplest cases. When successive advances of the sea follow successive retreats, such as occurred many times in the Upper Cretaceous—Lower Tertiary history of Egypt, the result is a complicated sedimentary and stratigraphic sequence. These compound features were first understood by Grabau (1924), and have recently been elaborated by Malkin and Jung (1941), Malkin and Echols (1948), Swain (1949) and Stetson (1949). Regression followed by transgression results in a wedge of shales pinching out downdip between two limestones, whereas transgression followed by regression results in an offshore wedge of limestone pinching out updip in a shoreward direction between two shale facies, which pinch out seaward.

Since the basin of deposition of the sections studied was an "interior" sea of limited extent, it is obvious that the sediments should have the form of a wedge that thickens seaward. Here the central part of the basin is close enough to the shore to receive thick deposits from all sides.

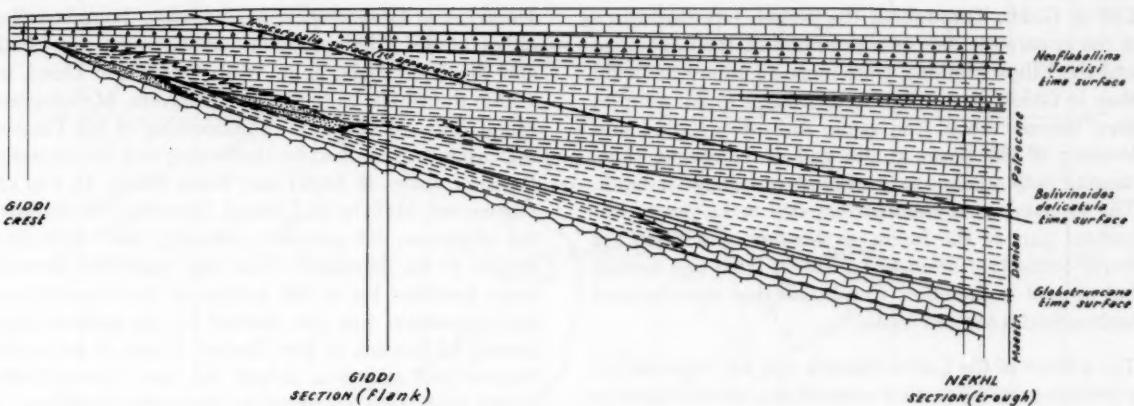
#### Time-surfaces

In order to understand the sedimentary history of this ancient basin of deposition, it is necessary to establish surfaces of contemporaneity so that one can segment

the deposits and attempt to apply the principles just outlined. These time-surfaces can be established only by paleontologic evidence. The value of fossils lies primarily in the fact that they can be used as indicators of synchrony. Unfortunately, not every fossil is sufficiently short-lived and widely distributed, irrespective of ecologic conditions, to warrant its use in geochronology. Many of the short-lived fossils are facies fossils that occur only under certain environmental conditions. These fossils are of local significance only, and cannot serve in reconstructing ancient time-surfaces.

Fossils that occur everywhere, irrespective of environment, from shoal water to the greatest depths, and that have a restricted time distribution, are excellent time-fossils. Those that appear only in a particular environment, such as the depths of a sea and not in its shallows, for example, are facies-fossils. A facies-fossil may be of local significance in chronology if it is short-lived. Among the most useful time-fossils that can be counted upon for zoning and for establishing time-surfaces are many of the species of *Globotruncana* and *Gümbelina*, which are found to occur in the deeper Nekhl Chalk and the contemporaneous shale of Giddi. The species of *Bolivinoides* and *Neoflabbellina* are also among the best time-fossils. They have a short vertical distribution and seem to survive different ecologic conditions. We have found these fossils so important that we have marked the Danian as the *Bolivinoides delicatulus* zone and the Paleocene as the *Neoflabbellina jarvisi* zone. We have abandoned the classic and oft-repeated zoning based on the planktonic foraminifera *Globigerina* and *Truncorotalia*. We feel that these forms are facies fossils, which may have some zoning value but which occur, like their descendants in modern times, only in open and moderately deep seas. The abundance of *Globigerina* species in the Danian of Nekhl, and their rarity or complete absence in the contemporaneous shale facies in Giddi, are most probably due to ecologic control. The same explanation may be given for the retardation of the appearance of *Truncorotalia* in Giddi, where this form did not appear until the area was completely flooded by the late Paleocene transgression. There are many other time-fossils, which will be dealt with in a later section. In text-figure 4 we have indicated the time-lines representing the upper limits of the appearance of *Globotruncana stuarti*, *Bolivinoides delicatulus*, and *Neoflabbellina jarvisi*. The line that shows the distribution of *Truncorotalia* species in this basin of deposition cuts the time-lines, and shows clearly the negligible value that these species have in constructing zones or in correlation.

## FORAMINIFERA FROM SINAI



TEXT-FIGURE 4

Idealized transverse section in the basin of deposition illustrating onlap and offlap, the most probable process that explains the distribution of sediments and foraminifera in space and time. First-appearance surface of *Truncorotalia* cuts time lines.

### Influence of this type of basin on foraminifera

The Maestrichtian is represented by the Chalk in the deeper Nekhl section, while it is represented by shale in the shallower Giddi section. It is obvious that, although the two sections contain certain species in common, there are others that fail to appear in one or the other area. Representatives of the family Ellipsoidinidae are more abundant at Nekhl than at Giddi, being forms that thrived in depths better than in the shallows. There are some twenty-three species of the family Lagenidae in Nekhl, with a benthonic foraminiferal number of 1.27. There are only sixteen species of this family in Giddi, making a foraminiferal number of 0.44. In the shallow area of Giddi, species of the genus *Frondicularia* are more abundant, while in the deeper Nekhl area, species of *Dentalina* and *Marginulina* seem to flourish. *Virgulina navarroana* and *Virgulina* sp., like their Recent descendants, are restricted to the deeper waters. The foraminiferal numbers of the arenaceous species in both sections are about the same (1.39 in Nekhl and 1.58 in Giddi), but the number of species in the two sections is different. There are at least twenty species in Nekhl, while there are only twelve species in Giddi. It is interesting to note that an abundance of species of arenaceous foraminifera seems to indicate deeper marine conditions (Glaessner, 1945; Galloway, 1933). Stainforth (1952a) has recently suggested that a turbid-water environment seems to be essential for the development of wholly arenaceous assemblages. In cases, however, where calcareous and arenaceous forms coexist, the classic idea that these forms indicate deep marine

conditions seems to be true, although it appears that the depth does not affect the total number of individuals so much as it affects the number of species.

The total benthonic foraminiferal numbers of the Maestrichtian of the two areas are about the same, being about 7.48 in Nekhl and 9.20 in Giddi. Four species make up more than one-third of these figures: *Buliminella laevis*, *Buliminella cushmani*, *Gyroidina girardana*, and *Anomalina pseudoacuta*.

The oncoming of the Danian was marked by a regression. The Nekhl Maestrichtian was followed by shales of the nearshore facies, while in Giddi littoral conditions prevailed, and the sea seems to have retreated, leaving the crest of the structure completely uncovered and subject to erosion. This may be the reason for the unconformity that is known to exist at the crest of this structure. It must be remembered, however, that the Danian shale of Nekhl is more calcareous, has a lower clastic ratio, and is thicker. The Nekhl section contains a greater number of representatives of the Globigerinidae than the littoral Giddi section. *Enantiomorphina*, *Enantiovaginulina*, and *Rectogumbelina* seem to indicate deeper-water conditions, as they are found only in Nekhl. Again, the representatives of the Lagenidae and Ellipsoidinidae are more abundant in Nekhl than in Giddi, with regard to both the number of species and the number of individuals.

The Paleocene appears to have begun with a minor transgression that continued, with minor regressions, throughout the period. The total benthonic foraminiferal number of the Paleocene samples is smaller than

those of the earlier samples, being 1.95 in Nekhl and 2.80 in Giddi. Throughout the period, representatives of the apparently deeper-water families, the *Lagenidae* and the *Ellipsoidinidae*, were more abundant in Nekhl than in Giddi, except that in the higher Giddi samples they become about the same, indicating filling and leveling of the basin at the end of Paleocene time, causing both sections to be of more or less equal depth. The arenaceous representatives still make up an important part of the fauna of this age, and there are fewer forms that seem to be absent from one section but present in the other. Conditions thus seem to have approached a leveled basin.

The advent of the Lower Eocene was accompanied by a great transgression that covered this leveled basin as well as the crest. This transgression is represented in all parts of the structure by limestone facies and moderately deeper-water faunas.

#### TECTONIC CONTROL OF OCCURRENCE OF FORAMINIFERA IN OTHER AREAS OF EGYPT

If our idea that the rugged configuration of the late Cretaceous sea bottom had some effect on the composition of the faunas is true, does it hold true of other areas of Egypt? Can this assumption explain the presence of the discrepancies outlined in the previous sections, in the temporal and spatial distribution of foraminifera as reported by other workers? There are nine Upper Cretaceous—Lower Tertiary sections in Egypt that have been studied: Six by Nakkady (1951), two by Osman (1954), and one by LeRoy (1953). Text-figure 5 shows the locations of these sections with regard to their position in the Syrian swell system of folds.

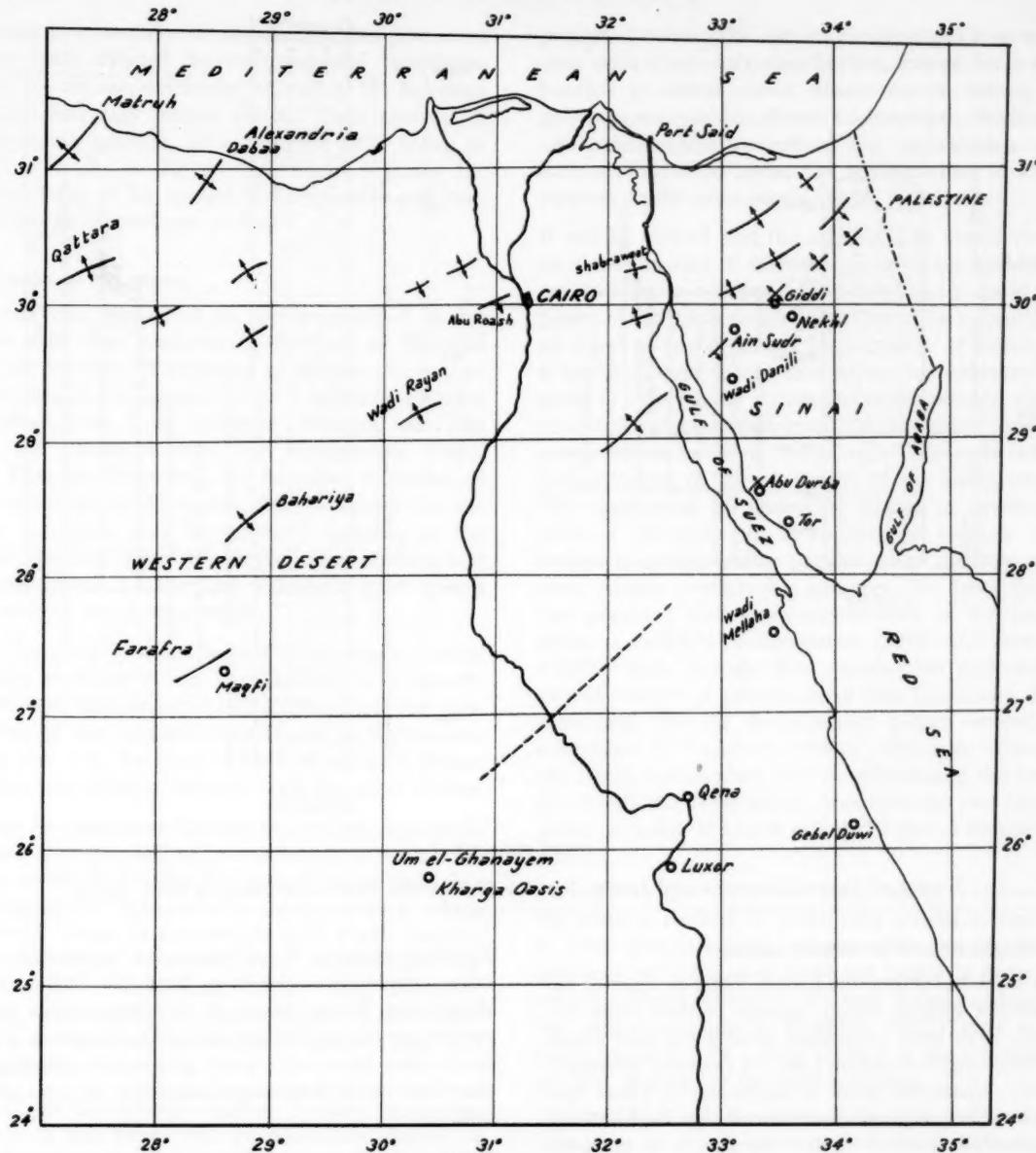
Since none of these authors realized the importance of *Bolivinoides* and *Neoflabellina* in zoning and correlating strata, we are unable to know the limits of their Danian and Paleocene, although at least part of Nakkady's "buffer zone" coincides with our Danian. The only common time-surface recognized by all these authors is the well-defined *Globotruncana-Gümbelina* boundary, which we have therefore used in comparing our sections with theirs.

It will be seen that, in those sections that lie on the flanks of the ancient structural highs (Abu Durba, Ain Sudr and Qabeliat), the *Globotruncana-Gümbelina* upper boundary lies within the Esna shale formation, indicating that at these localities shallow-water conditions must have prevailed in late Maestrichtian time. In those localities which presumably lay in the troughs

(Wadi Danili, Mellaha, Duwi, Um el-Ghanayem and Maqfi), the *Globotruncana-Gümbelina* boundary lies either at the lithologic boundary between the Chalk and the Esna shale, as in Wadi Danili and Duwi, or within the Chalk, as in Um el-Ghanayem, Mellaha and Maqfi. This denotes that the oncoming of the Danian regression was marked by shallowing and the accumulation of shales in Duwi and Wadi Danili. In Um el-Ghanayem, Mellaha and Maqfi, however, the shallowing of the sea did not affect lithology, and chalk continued to be deposited. This was probably because these localities lay in the middle of deep troughs, so that deposition was not affected by the general shallowing of the sea in the Danian. There is reason to believe that such was indeed the case. Bubnoff diagrams that were prepared to show the thickness of Mesozoic strata along the Egyptian side of the Gulf of Suez show that the Duwi-Mellaha area constituted a deep basin, which was deeper toward Mellaha. This basin followed the Erythrean trend (Shukri and Said, in press). It may be recalled that the Gulf of Suez graben was initiated at some time in the Paleozoic, and that toward the north, at least near Mellaha, this graben remained for a long time a deep gulf that was affected by the older Syrian swell system (Said and Shukri, in press), thereby producing a deep area. It is for this reason that this area is the only locality in Egypt, outside northern Sinai, where Lower Cretaceous Albian strata are recorded (van der Ploeg, 1953), indicating a gulf-like extension of the Lower Cretaceous sea in this tectonically low area. Um el-Ghanayem and Maqfi, on the other hand, lie in the heart of the southern Western Desert, where the great basin of the Upper Cretaceous sea was affected but little by the Syrian swell system (Shukri, 1954).

The Maestrichtian-Danian boundary is therefore of importance in determining the structural position of the locality from which a section was taken. When this boundary coincides with the lithologic boundary between the Chalk and the Esna shale, it indicates a structural low, whereas its occurrence within the Esna shale indicates a structural high in the late Cretaceous sea. This idea is further strengthened by the fact that we find the thinnest Danian, followed immediately by the *Truncorotalia* zone, in the structurally low areas. In Nekhl the beginning of the *Truncorotalia* zone is separated from the Maestrichtian by 20 meters; in Mellaha, which occupied the deep trough discussed above, the Danian is only 1 meter thick, and in Duwi it is only 8 meters thick, thus denoting that these localities were situated in deeper areas, so that when *Truncorotalia* species first appeared they accumulated in these open parts of the ancient sea.

## FORAMINIFERA FROM SINAI

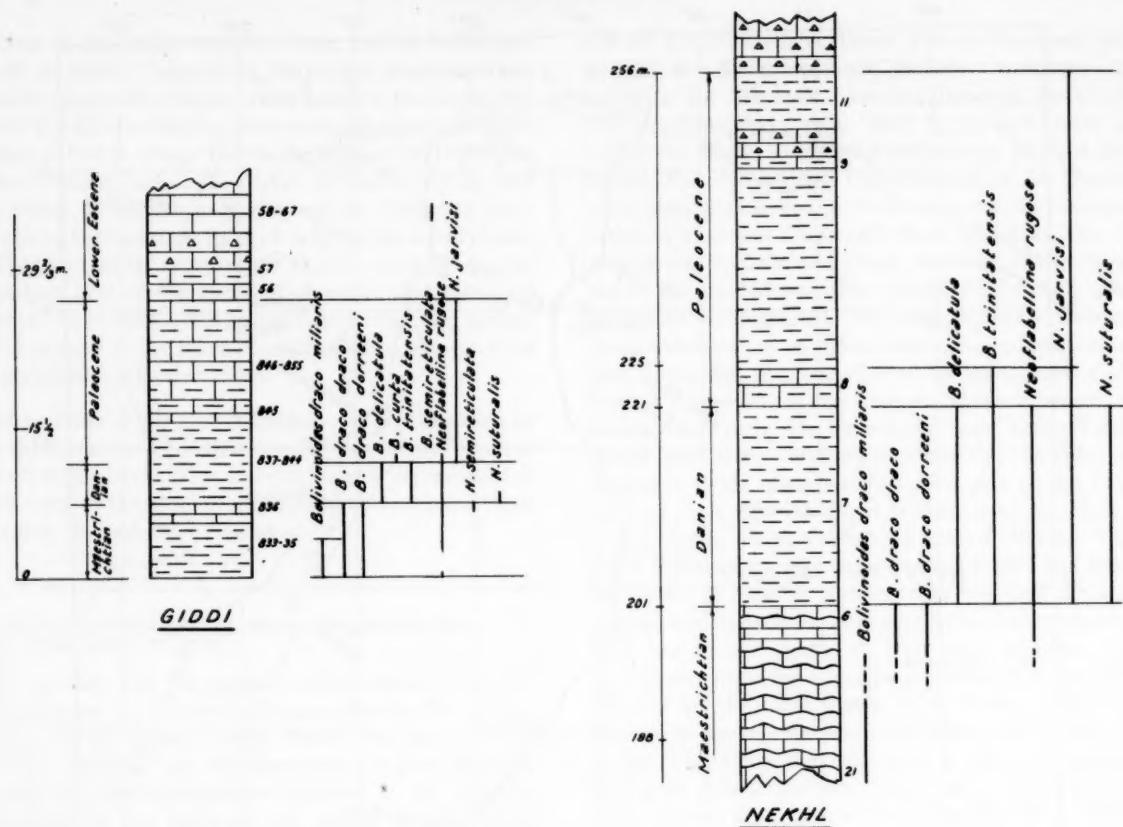


**TEXT-FIGURE 5**

Map of part of Egypt showing location of sections studied in relation to the Syrian-swell structural trend.

On the other hand, the appearance of *Truncorotalia* species in the flank sections was retarded, thus leaving the "buffer zone" much thicker. If we compare Giddi with Nekhl, we see that the "buffer zone" in the former is 30 meters thick, while it is 20 meters thick in the latter although the sediments of the trough should be thicker.

It appears, therefore, from the above discussion, that tectonic control of the appearance of foraminiferal species holds true in almost all the sections studied thus far in the Upper Cretaceous and Lower Tertiary of Egypt. There is no doubt that more detailed statistical work must be done on many more sections before the validity of the theory advanced in this work is established.



TEXT-FIGURE 6

Ranges of Upper Cretaceous and Lower Tertiary *Bolivinoides* and *Neoflabellina* in Sinai, Egypt.

#### STRATIGRAPHIC VALUE OF CERTAIN SPECIES

This work has shown the limited value of some of the planktonic species, which, because of their rapid dispersal, have been considered among the best fossils for long-range correlation (see, for example, Stainforth (1951), where this point is emphasized). These species, however, as pointed out recently by Todd (1954), are generally limited in their occurrence to open-sea facies, and thus are available for correlation between such facies only. The present work has shown that in Egypt, where the bottom topography of the Upper Cretaceous—Lower Tertiary sea was affected by great lateral folding movements, environmental conditions may differ from one place to another rather rapidly, and this makes the use of planktonic species of rather limited value.

The only exceptions to this rule seem to be the *Globotruncana* and *Gümbelina* species, which are assumed by many authorities to have been planktonic. In the

Egyptian material, these species are associated with other characteristic fossils in both the shallow- and deep-water facies, hence it is believed that these species are among the best index fossils known. These fossils also have such wide geographic distribution that their use in long-range correlation likewise seems feasible.

Benthonic species are believed to be more responsive to variations in the sedimentary environment, and are therefore of possible use in explaining local paleoecologic conditions. Such is indeed the case in the material studied in this work. A greater variety of arenaceous forms, together with abundance in the number of species and individuals of the Lagenidae and the Ellipsoidinidae, seems to indicate deep-water conditions. Certain benthonic species, however, also seem to be excellent time-indicators for long-range correlation, irrespective of the environment. Among these, the species of *Bolivinoides*, *Neoflabellina* and *Stensiönia*

## FORAMINIFERA FROM SINAI

not only have world-wide distribution, but also seem to be little affected by environmental conditions. These species are, unfortunately, rare in the Egyptian material and may escape notice. These species, as stratigraphic markers, have received little notice in previous works on Egypt. Text-figure 6 shows the vertical range of the species of *Bolivinoides* and *Neofabellina* in the sections studied.

### THE ORIGIN OF THE FAUNA

A remarkable feature of the fauna described in this paper is its close similarity to the fauna of Trinidad and the Tampico Embayment of Mexico. More than 70 per cent of the Egyptian fauna is identical with that described from those localities (compare our lists with the statements made by Bronnimann, 1952). The Egyptian Paleocene, for example, is similar to the Lizard Springs formation, thus indicating that the latter formation may be correctly assigned to the Lower Tertiary, since the stratigraphic position and macrofossils of the Egyptian Paleocene point to this age without much controversy.

The European element in this Cretaceous—Lower Tertiary sequence is very small indeed. It is interesting to note that Ansary (1955) found that the composition of the Upper Eocene faunas of Egypt compares well with the North American standard section but has very little in common with European faunas.

It may be worth mentioning that preliminary results of some monographic studies carried out in our laboratories on the foraminiferal faunas of Egypt show that the Cretaceous represents the oldest period in which migratory routes or connections with North America were established. Egyptian Jurassic faunas (Said and Barakat, MS.) show great affinity with European faunas, while Paleozoic faunas show a close resemblance to those of the Pacific province (Said and Shukri, MS.).

The Upper Cretaceous—Lower Tertiary faunas described in this paper also include many species in common with the American Gulf Coast region. One feature needs emphasis: Many of the typical American Taylor species are here found in the Maestrichtian, which is generally correlated with the American Navarro (Stephenson *et al.*, 1942). The reason for this lag in their appearance in Egypt is not fully understood. It may be a result of homotaxy.

### NOTE ON THE SYSTEMATICS

About 275 species of foraminifera from the two Upper Cretaceous and Lower Tertiary sections studied are

presented below. The species are arranged in accordance with Cushman's classification, except for a few families in which recent discoveries or restudy of genotype material has altered the concepts, elucidated new relationships, or refined the classification. We have attempted to revise the nomenclature so as to conform to the most recent usage.

It will be noticed that the authors have drawn freely on a vast amount of literature, both classic and modern, in order to redefine the concepts and limits of the genera of foraminifera recognized here. The authors feel no regret at having used a large number of names, as it is the authors' belief that names are necessary in order to indicate the multitudinous varieties of structural detail and morphological and anatomical features present in foraminifera, and in order to promote better understanding of the phylogeny of the foraminifera. The application of systematic names to specimens showing variations in morphological features and structural details makes possible more accurate and more precise stratigraphic zonation. We have therefore accepted Galloway's classification of the Lagenidae, as modified by Bartenstein (1948) and Brotzen (1953), even though this classification includes a greater number of generic names than Cushman's. The same holds true for the numerous genera revived or established by Stainforth (1952b, 1952c) for uniserial calcareous foraminifera. The classification of the families Rotaliidae, Nonionidae, Anomalinidae and Globigerinidae followed here is essentially that of Bermudez (1952).

Throughout this systematic study we have followed the classical method of identifying species according to their morphological features, although in many instances we have used clarifying media in order to see the internal structures. We have found anisine oil, first used successfully by Höglund (1947), most satisfactory in giving us a clear picture of the systematic position of many of the smaller forms.

The study of microanatomical structures of foraminifera has in recent years produced a wealth of information on the structure, evolution and relationships of the genera. Studies such as those of Brotzen, Höglund and Hofker have had a marked influence on the taxonomy of the entire order.

Recognition is given to the numerous works of Hofker, particularly to his voluminous report on the foraminifera of the Siboga Expedition (1951), in which he established many new genera and erected a new classification on the basis of his elaborate studies of the internal structure, apertural (foraminal) characters, and wall perforations. Throughout this work

we have been guided by Hofker's conclusions, but we have found that it is impossible, at present, to follow his revolutionary classification because it is, as yet, incomplete. Although we are inclined to agree with many of Hofker's ideas, as will be evident from the following text, we find that, until the microstructure of all genera has been studied, Hofker's classification must remain tentative and is impracticable to follow.

Types are deposited in the collections of the United States National Museum (U.S.N.M.), Washington, D. C.

#### SYSTEMATIC DESCRIPTIONS

##### Family RHIZAMMINIDAE

###### Genus BATHYSIPHON M. Sars, 1872

###### *Bathysiphon* (?) *dubia* (White)

Plate 1, figure 1

*Kalamopsis dubia* White, 1928, Jour. Pal., vol. 2, p. 185, pl. 27, fig. 3.

A few specimens of this species were found in sample no. 837, Giddi. None of the specimens shows a proloculum, and the species is here placed in *Bathysiphon*, although with some question. The specimens fit the measurements and descriptions of this Mexican species, but the wall is more roughly finished.

Figured specimen (U.S.N.M. P3938) and unfigured specimen (U.S.N.M. P3939) from sample 837.

##### Family AMMODISCIDAE

###### Genus INVOLUTINA Terquem, 1862

###### *Involutina* *cretacea* (Reuss)

Plate 1, figure 4

*Operculina* *cretacea* Reuss, 1845, Verstein. Böhm. Kreideform., pt. 1, p. 35, pl. 13, figs. 64-65.

*Ammodiscus* *cretaceus* (Reuss).—CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 17, pl. 1, fig. 35.

Typical specimens of this species occur in sample no. 7, Nekhl, and the supposedly contemporaneous samples no. 837 and 839, Giddi. This species has a restricted vertical distribution in the Egyptian Danian, and may be of importance in dating rocks and correlating strata independently of facies. It has this restricted occurrence in North America (Navarro) and Mexico (Mendez), but appears to range from the Lower to the Upper Cretaceous in Europe. Our specimens average about 1 mm. in diameter. The chambers are numerous and increase gradually and uniformly as added.

Figured hypotype (U.S.N.M. P3940) from sample 7.

###### *Involutina* sp. Plate 1, figure 5a-b

Test planispiral, closely coiled, slightly involute; chambers increasing gradually and uniformly in size as added, with many whorls, often with conspicuous increase in the thickness of the chambers; periphery truncate; sutures distinct, depressed; wall very finely arenaceous with much calcareous cement, smooth, usually white and fairly thin; aperture formed by open end of the tube.

This species differs from *Involutina cretacea* in being smaller in diameter, in having a depressed initial end, and in having a truncate periphery.

A few specimens of this species were found in Paleocene sample no. 11, Nekhl; it has a localized occurrence.

Figured specimen (U.S.N.M. P3941) from sample 11.

###### *Involutina tenuissima* (Gümbel)

*Ammodiscus tenuissimus* (Gümbel).—BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 267, pl. 1, fig. 14.

A few specimens of this species occur in sample no. 6, Nekhl. Our specimens are comparable with those recorded by Bartenstein and Brand from the Upper Valensis of Germany in having a very thin test and obliterated sutures.

Unfigured hypotype (U.S.N.M. P3942) from sample 6.

##### Genus GLOMOSPIRA Rzehak, 1885

###### *Glomospira* *charoides* *leroyi* Said and Kenawy, new variety Plate 1, figure 6

Variety differing from the typical form in having the irregularly coiled later portion in the form of a depressed crown coiling about the whole test, and in having a more smoothly finished test.

This variety is restricted to the Danian samples in both the Nekhl area (no. 7) and the Giddi area (no. 839), and occurs in small numbers.

Holotype (U.S.N.M. P3943) from sample 7.

###### *Glomospira gordialis* (Jones and Parker) Plate 1, figure 7

*Trochammina squamata* *gordialis* JONES AND PARKER, 1860, Quart. Jour. Geol. Soc. London, vol. 16, p. 304.  
*Glomospira gordialis* (Jones and Parker).—CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 18, pl. 1, figs. 38-40. — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 267, pl. 1, figs. 15-16.

A few specimens of this species occur in the Maestrichtian sample no. 6 of the Nekhl section. They are comparable to those recorded from the Gulf Coast region and

## FORAMINIFERA FROM SINAI

Mexico in contemporaneous horizons, although in the latter area they appear to pass upward into the Lizard Springs formation of Trinidad.

Hypotype (U.S.N.M. P3944) from sample 6.

### Genus *LITUOTUBA* Rhumbler, 1895

#### *Lituotuba* cf. *L. lituiformis* (H. B. Brady) Plate 1, figure 2

*Lituotuba lituiformis* (Brady). — CUSHMAN AND RENZ, 1946, Cushman Lab. Foram. Res., Spec. Publ. 18, p. 15, pl. 1, figs. 32-33.

A few specimens that seem to belong to this species are recorded from the Paleocene sample no. 9, Nekhl. Our specimens resemble those recorded by Cushman and Renz from the supposedly contemporaneous Lizard Springs formation of Trinidad, although the Egyptian specimens have a more regularly coiled initial end.

Figured specimen (U.S.N.M. P3945) from sample 9.

### Family LITUOLIDAE

#### Genus *HAPLOPHRAGMOIDES* Cushman, 1910

##### *Haplophragmoides eggeri* Cushman Plate 1, figure 3

*Haplophragmoides eggeri* CUSHMAN, 1926, Bull. Amer. Assoc. Petrol. Geol., vol. 10, p. 583, pl. 15, fig. 1a-b.

Specimens that resemble those of the Corsicana marl of the Navarro group of the Gulf Coast area are found in sample no. 837, Giddi. These specimens have a rough exterior, indistinct sutures, and fewer chambers.

Hypotype (U.S.N.M. P3946) from sample 837.

#### Genus *AMMOBACULITES* Cushman, 1910

##### *Ammobaculites schwageri* Said and Kenawy, new species Plate 1, figure 8

Test elongate, coarsely arenaceous and more or less roughly finished, the first four or five chambers arranged planispirally in a thick, non-umbilicate coil, the succeeding few chambers rectilinear, broader than high, oval in cross section; sutures not visible, very slightly depressed; aperture terminal, round or somewhat elongate. Length 1 mm.

This species has a restricted range (the Paleocene samples of Giddi, no. 847 and 852). It differs from *Ammobaculites eocretaceus* Bartenstein and Brand in having a much less open umbilicus, a more rounded aperture, and a more smoothly finished test.

Holotype (U.S.N.M. P3947) from sample no. 847, Esna shale, Giddi.

### Family TEXTULARIIDAE

#### Genus *SPIROPLECTAMMINA* Cushman, 1927

##### *Spiroplectammina dentata* (Alth) Plate 1, figure 9

*Textularia dentata* ALTH, 1850, Haidinger's Naturwiss. Abh., vol. 3, p. 262, pl. 13, fig. 13.

*Spiroplectammina dentata* (Alth). — CUSHMAN AND JARVIS, 1932, Proc. U. S. Nat. Mus., vol. 80, art. 14, p. 14, pl. 3, fig. 7a-b.

Specimens of this species as described by Cushman and Jarvis from the Lizard Springs formation of Trinidad occur in large numbers in samples no. 837, 838, 839, 840, 842, 843, 847 and 852, Giddi. The specimens have the spinose projections of the chambers drawn out from the middle of the periphery. In Egypt this species ranges from the Danian to the Paleocene.

Hypotype (U.S.N.M. P3948) from sample 837.

##### *Spiroplectammina henryi* LeRoy Plate 1, figure 11

*Spiroplectammina henryi* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 50, pl. 2, figs. 14-15.

Typical specimens of this well-defined and characteristic species occur in our material in samples no. 8 and 9, Nekhl. This species has been recorded by LeRoy from the upper part of his unit A (Maestrichtian) in the Western Desert, but seems to occur at a higher level in the Sinai material. Whether this occurrence is attributable to homotaxy, or to the long range of this species, or to some error in dating by LeRoy, is not clear. LeRoy did not give the exact range of this species in his distribution chart, and did not explain precisely the nature of his Maestrichtian unit A assemblage, which, in his words, was given "moderate consideration" in his paper. It is obvious, however, from the data given by LeRoy, that this species, together with *Spiroplectammina knebeli*, occur at a higher level than LeRoy's *Globotruncana* zone.

Hypotype (U.S.N.M. P3949) from sample 8.

##### *Spiroplectammina knebeli* LeRoy Plate 1, figure 10

*Spiroplectammina knebeli* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 51, pl. 2, figs. 10-11.

Typical specimens of this species are recorded from the Giddi section in samples no. 847, 852 and 859, mostly of Paleocene age. LeRoy records this species only from his Maestrichtian unit A, but in the Sinai material it seems to have a longer range.

Hypotype (U.S.N.M. P3950) from sample 852.

## SAID AND KENAWY

### ***Spirolectammina knebeli longa***

Said and Kenawy, new variety  
Plate 1, figure 12

Variety differing from the typical form in having the test longer in relation to its width, and in having less flaring later chambers.

This variety occurs in the Giddi area in samples no. 838 and 843. It is closely related to the typical form and may have given rise to it, as the typical form occurs in the same area at a slightly higher level.

Holotype (U.S.N.M. P3951) from sample 843.

### ***Spirolectammina paracarinata* Said and Kenawy, new species**

Plate 1, figure 13

Test compressed, about one and one-half times as long as broad; periphery keeled and acute, the ends of some chambers extended out in spinose projections; chambers distinct, twice as broad as high, numerous; sutures distinct, depressed, slightly curved, making an angle of about 30° with the horizontal; wall finely arenaceous with much cement, smoothly finished.

This species differs from *Spirolectammina dentata* in having fewer and higher chambers, in having less developed spinose projections from the chambers, and in having a thicker and stouter test with a more rounded cross section at the apertural end. This species is related to *Spirolectammina dentata* and may have developed from it.

A few specimens of this species are recorded from sample no. 859, Giddi. The holotype (U.S.N.M. P3987) comes from this sample.

### Genus **TEXTULARIA** Defrance, 1824

#### ***Textularia farafrensis* LeRoy**

Plate 1, figure 14

*Textularia farafrensis* LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 51, pl. 2, figs. 3-4.

Specimens that are identical with those recorded by LeRoy from the Western Desert of Egypt occur in small numbers in sample no. 842, Giddi. With this record, this species ranges from the Paleocene to the Lower Eocene.

Hypotype (U.S.N.M. P3952) from sample 842.

### Genus **VULVULINA** d'Orbigny, 1826

#### ***Vulvulina colei* Cushman**

Plate 1, figure 15

*Vulvulina colei* CUSHMAN, 1932, Contr. Cushman Lab. Foram. Res., vol. 8, p. 84, pl. 10, figs. 21-22. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 400, pl. 1, fig. 6. — LE ROY, 1953, Geol. Soc. Amer., Mem. 54, p. 54, pl. 8, fig. 23.

Specimens that seem to belong to this species were found in sample no. 7, Nekhl, and in samples no. 839, 840, 847, 852 and 861, Giddi. The distribution of this species is unique, as it is here recorded from deposits as old as Danian. It is possible that the occurrence of this species is one of the reasons for the usage of such terms as Dano-Paleocene or Dano-Montian for the lower beds that are here referred to the Danian. The genus *Vulvulina* has been recorded from deposits as old as the Lizard Springs by Cushman and Renz (1946). Our specimens have the early planispiral depressed part well developed and clear.

Hypotype (U.S.N.M. P3953) from sample 847.

## Family VERNEUILINIDAE

### Genus **VERNEUILINA** d'Orbigny, 1839

#### ***Verneuilina aegyptiaca* Said and Kenawy, new species**

Plate 1, figure 16

Test short, tapering, triangular in transverse section but with rounded angles, sides flattened or slightly convex; chambers not distinct, slightly inflated, increasingly rapidly in size as added; sutures not distinct, slightly depressed, rather strongly curved; wall coarsely arenaceous, not smoothly finished; aperture a narrow semicircular opening at the base of the last-formed chamber. Length 0.5 mm.; breadth 0.5 mm.

This species differs from *Verneuilina karreri* in having more rounded angles, in being shorter and smaller, and in having the chambers more inflated.

In our material this species has a wide vertical range, occurring sporadically in practically all Maestrichtian, Danian and Paleocene samples of both Giddi and Nekhl. It is recorded only in the shale samples and may therefore be a facies fossil.

Holotype (U.S.N.M. P3954) from sample no. 833, Esna shale, Maestrichtian, Giddi.

#### ***Verneuilina karreri* Said and Kenawy, new species**

Plate 1, figure 17

*Verneuilina cretacea* Karrer. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 405, pl. 3, fig. 1.

Test slightly elongate, tapering, slightly longer than broad, sharply triangular in transverse section, sides flattened or concave; chambers not distinct, of uniform shape, regularly and rapidly increasing in size as added; sutures not distinct, slightly depressed, rather strongly curved, the angles of the chambers somewhat carinate; wall coarsely arenaceous, roughly finished; aperture a narrow high slit at the inner margin of the last-formed chamber. Length 0.8 mm.; breadth 0.5 mm.

This species is recorded in large numbers in samples no.

## FORAMINIFERA FROM SINAI

833, 834, 835, 837, 838, 839, 840 and 842, Giddi, and in sample no. 6, Nekhl.

Holotype (U.S.N.M. P3955) from sample no. 840, Esna shale, Danian, Giddi.

### Genus *TRITAXIA* Reuss, 1860

#### *Tritaxia barakai* Said and Kenawy, new species Plate 1, figure 18

Test elongate, pyramidal, broadest near apertural end, regularly tapering to the pointed initial end, triserial, triangular in transverse section, angles sharply acute, sides flattened; chambers numerous, rather indistinct, not inflated, increasing slowly in size as added; sutures rather indistinct, slightly depressed, nearly at right angles to the axis of the test; wall arenaceous, rather smoothly finished; aperture in the adult terminal, rounded, slightly protuberant. Length 0.6 mm.; breadth 0.35 mm.

This species is closely related to *Tritaxia pyramidata* Reuss, but differs in being small in size and in having much sharper angles and less oblique sutures. A small number of specimens was found in the Maestrichtian samples no. 6, Nekhl, and no. 833 and 834, Giddi.

Holotype (U.S.N.M. P3956) from sample no. 6, Chalk, Maestrichtian, Nekhl.

#### *Tritaxia dubia* (Reuss) Plate 1, figure 19

*Tritaxia dubia* (Reuss). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 26, pl. 4, figs. 1-4.

A few specimens that are identical with those recorded from the upper Senonian of Europe are found in samples no. 6, Nekhl, and no. 837 and 838, Giddi. There is some variation in the material with regard to the elongation of the test, degree of smoothness of the wall, and eversion of the aperture.

Hypotype (U.S.N.M. P3957) from sample 6.

### Genus *GAUDRYINA* d'Orbigny, 1839

#### *Gaudryina aissana* ten Dam and Sigal Plate 1, figure 20

*Gaudryina (Siphogaudryina) aissana* TEN DAM AND SIGAL, 1950, Contr. Cushman Found. Foram. Res., vol. 1, p. 31, pl. 2, fig. 2a-b.

Specimens very similar to those recorded by ten Dam and Sigal from the Dano-Montian of Algeria were found in sample no. 6, Nekhl. The inflated chambers of the biserial part show more regularity than those of the specimen figured by ten Dam and Sigal.

Hypotype (U.S.N.M. P3958) from sample 6.

#### *Gaudryina elegantissima* Said and Kenawy, new species Plate 1, figure 21

Test elongate, small for the genus, earliest portion triserial, becoming biserial early in the development; chambers distinct, very slightly inflated, eight in the adult biserial portion, very gradually increasing in size as added, slightly broader than high; sutures distinct, depressed; wall arenaceous with a large proportion of cement, smooth; aperture a semicircular opening at the base of the last-formed chamber. Length 0.4 mm.; breadth 0.2 mm.

A number of specimens of this well-defined species occur in the contemporaneous samples no. 7 and 8 from Nekhl and no. 837-842, 848 and 852 from Giddi.

Holotype (U.S.N.M. P3959) from sample no. 842, Giddi.

#### *Gaudryina laevigata* Franke Plate 1, figure 22

*Gaudryina laevigata* FRANKE, 1914, Deutsch. Geol. Ges., Zeitschr., vol. 66, p. 431, pl. 27, figs. 1-2. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 33, pl. 8, fig. 4. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 402, pl. 1, fig. 8.

Specimens similar to those known from the Upper Cretaceous of Europe were found in samples no. 6, 7 and 8, Nekhl, and no. 847, 848 and 852, Giddi. This species shows great variation in shape, in the length of the test, in the compression of the biserial part, and in the angularity of the early triserial portion. This species is here considered to include only those forms with a smoothly finished wall, a short early triserial part, and a slightly depressed biserial part. Specimens that are exactly identical with these but have a coarsely finished wall were found in sample no. 862, Lower Eocene, Giddi.

Hypotype (U.S.N.M. P3960) from sample 852.

#### *Gaudryina limbata* Said and Kenawy, new species Plate 1, figure 23

Test elongate, triangular in transverse section, the early chambers triserial, later biserial, angles acute; chambers distinct, not inflated, numerous, in the biserial portion with the series of one side having a truncate periphery, those of the opposite series pointed; sutures distinct, slightly limbate; wall finely arenaceous and very smoothly finished; aperture a low opening in a semicircular re-entrant of the inner margin of the last-formed chamber. Length 0.55 mm.; breadth 0.35 mm.

This species differs from *Gaudryina pyramidata* in being more elongate and in having more chambers, sharper edges, limbate sutures, and a smoothly finished surface. It shows some variation in the development of the last-formed chambers, which are sometimes depressed.

This species occurs in large numbers in the Giddi samples no. 837, 839, 840, 842, 847, 852, 859 and 862. Its first appearance in this section is of some stratigraphic significance.

Holotype (U.S.N.M. P3961) from sample no. 840, Esna shale, Danian, Giddi.

**Gaudryina nekhensis** Said and Kenawy, new species  
Plate 1, figure 24

Test elongate, tapering, two and one-half times as long as broad, greatest breadth at the beginning of the biserial portion; early portion triserial, triangular in section, comprising about one-fifth of the entire test, tapering toward the initial end; biserial portion with sides almost parallel in the later portion, distinctly quadrangular in section, with more or less rounded angles; chambers indistinct in the triserial portion, distinct in the biserial part, six in number, distinctly inflated, giving a lobed appearance to the test, but with no overlapping; sutures indistinct, depressed, particularly on the sides, where they are nearly straight; wall arenaceous, more or less smoothly finished; aperture rounded, removed from the base of the last-formed chamber, more or less terminal. Length 1.4 mm.; breadth 0.8 mm.

This species differs from *Gaudryina aissana* in having a smaller number of chambers in the biserial part, in having a median suture that is less sinuous, and in having a terminal aperture. The apertural characters of this species are unique; they are somewhat intermediate between those of *Gaudryina* and those of *Bermudezina*.

This species occurs in large numbers in the upper Paleocene sample no. 11, Nekhl. The holotype (U.S.N.M. P3962) comes from this sample.

**Gaudryina cf. G. rugosa** d'Orbigny  
Plate 1, figure 25

*Gaudryina* (*Gaudryina*) *rugosa* d'Orbigny. — CUSHMAN, 1937 (part), Cushman Lab. Foram. Res., Spec. Publ. 7, p. 36, pl. 4, figs. 14-16 (non figs. 17-19); pl. 5, figs. 1-2. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 403, pl. 2, fig. 3.

A large number of specimens that show great variation are here grouped together under this name. The typical form has a triserial part that makes up one-third of the entire test and is not distinct from the later biserial part, which is transversely rectangular. The specimens vary in the distinctness of the sutures, the coarseness of the test, and the amount of depression of the biserial part.

This species occurs in samples no. 7, 8, and 9, Nekhl, and no. 842, 844, 847, 848 and 852, Giddi.

Hypotype (U.S.N.M. P3964) from sample 7.

**Gaudryina pyramidata** Cushman  
Plate 1, figure 26

*Gaudryina laevigata pyramidata* CUSHMAN, 1926, Bull. Amer. Assoc. Petrol. Geol., vol. 10, p. 587, pl. 16, fig. 8a-b.

*Gaudryina* (*Pseudogaudryina*) *pyramidata* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 36, pl. 8, fig. 14. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 403, pl. 2, fig. 1. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 31, pl. 1, figs. 17-18.

This species occurs in large numbers in samples no. 6 and 7, Nekhl, and no. 833-839, Giddi. This is a well-defined species, although it varies gradually toward *Gaudryina rugosa* and *Gaudryina laevigata*, which causes difficulty in identification.

In Egypt this species has been recorded by LeRoy as occurring in the upper part of his Maestrichtian unit A, and was indicated by Osman as an index fossil for the lower Maestrichtian of the Qabeliat section. In our material it occurs abundantly in the lower Maestrichtian but ranges into the Danian; its vertical distribution here thus approaches its range at the type locality in Mexico.

Hypotype (U.S.N.M. P3963) from sample 6.

**Gaudryina soldadoensis** Cushman and Renz  
Plate 1, figure 27

*Gaudryina soldadoensis* CUSHMAN AND RENZ, 1942, Contr. Cushman Lab. Foram. Res., vol. 18, p. 4, pl. 1, fig. 2. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 404, pl. 2, fig. 4.

A few specimens of this species, originally described from the Soldado formation, Midway Eocene, of Trinidad, occur in the Lower Eocene sample no. 861, Giddi. The specimens differ slightly from the type in having a more quadrangular biserial portion.

Hypotype (U.S.N.M. P3965) from sample 861.

Genus **PSEUDOCLAVULINA** Cushman, 1936

**Pseudoclavulina amorpha** (Cushman)  
Plate 1, figure 32

*Clavulina amorpha* CUSHMAN, 1926, Bull. Amer. Assoc. Petrol. Geol., vol. 10, p. 589, pl. 17, fig. 5.

*Pseudoclavulina amorpha* (Cushman). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 37, pl. 9, figs. 3-4.

Numerous specimens of this species were found in samples no. 852 and 859, Giddi. They are exactly similar to those of the type locality in Trinidad. There are some other specimens in the Upper Cretaceous samples no. 6, Nekhl, and no. 835, Giddi, that may be referred to this species, although in the latter specimens the uniserial part is less developed and less broad than the early triserial part.

Hypotype (U.S.N.M. P3966) from sample 835.

## FORAMINIFERA FROM SINAI

### **Pseudoclavulina clavata** (Cushman)

Plate 1, figure 28

*Pseudoclavulina clavata* (Cushman). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 108, pl. 15, figs. 1-13. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 44, pl. 1, fig. 13.

Typical specimens of this species occur in large numbers in the Maestrichtian samples of both the Nekhl and the Giddi sections. This species continues in small numbers into the Paleocene. It was originally described from the Velasco shale of the Tampico Embayment of Mexico, but in Egypt it seems to be more abundant in the Maestrichtian.

Hypotype (U.S.N.M. P3967) from sample 6.

### **Pseudoclavulina farafricensis** LeRoy

Plate 1, figure 29

*Pseudoclavulina farafricensis* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 44, pl. 2, fig. 9.

Typical specimens of this species were found in samples no. 6, 9 and 11, Nekhl, and no. 833, 834 and 835, Giddi. The range of this species is given as "basal Eocene" by LeRoy, but in our material it extends from the Maestrichtian to the Paleocene.

Hypotype (U.S.N.M. P3968) from sample 835.

### **Pseudoclavulina globulifera** ten Dam and Sigal

Plate 1, figure 30

*Pseudoclavulina globulifera* TEN DAM AND SIGAL, 1950, Contr. Cushman Found. Foram. Res., vol. 1, p. 32, pl. 2, figs. 5-7.

A few specimens that are exactly identical with those described by ten Dam and Sigal from the Dano-Montian of Algeria are recorded from the Danian sample no. 7, Nekhl.

Hypotype (U.S.N.M. P3969) from sample 7.

### **Pseudoclavulina maqfiensis** LeRoy

Plate 1, figure 31

*Pseudoclavulina maqfiensis* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 44, pl. 2, figs. 16-17.

*Clavulina parisiensis* d'Orbigny. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 406, pl. 2, fig. 6.

Typical specimens of this species occur in samples no. 7, Nekhl, and no. 847 and 848, Giddi. The range of this species is given by LeRoy as Lower Eocene, but in our material it ranges from the Danian to the Paleocene.

Hypotypes (U.S.N.M. P3970) from sample 7.

### **Pseudoclavulina pseudoarenata** Said and Kenawy,

new species

Plate 1, figure 33a-c

Test elongate, cylindrical, early chambers triserial and triangular in section, later chambers uniserial; chambers

distinct, of uniform size, six in number in the uniserial part; sutures distinct, slightly depressed; wall coarsely arenaceous, surface rough; aperture terminal, rounded, with a very small neck. Length 1.5 mm.; breadth 0.4 mm.

In some specimens the early triserial part is twisted so as to be at right angles to the uniserial part. This species differs from *Pseudoclavulina arenata* (Cushman) in having a larger test, a slightly lipped aperture, and distinct chambers and sutures.

A few specimens of this species were found in sample no. 6, Esna shale, Maestrichtian, Nekhl. The holotype (U.S.N.M. P3971) comes from this sample.

## Genus CLAVULINOIDES Cushman, 1936

### **Clavulinoides algerianus** ten Dam and Sigal

Plate 1, figure 34

*Clavulinoides algeriana* TEN DAM AND SIGAL, 1950, Contr. Cushman Found. Foram. Res., vol. 1, p. 33, pl. 2, fig. 11.

Typical specimens of this Dano-Montian species of Algeria occur in small numbers in the lowermost Paleocene sample no. 842, Giddi. The more or less smoothly finished surface and the more elongate triserial portion distinguish this species from related species.

Hypotype (U.S.N.M. P3972) from sample 842.

### **Clavulinoides asper** (Cushman)

Plate 1, figure 36

*Clavulinoides asper* (Cushman). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 122, pl. 16, figs. 27-31, pl. 17, figs. 1-3. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 38, pl. 9, figs. 24, 30. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 25, pl. 1, figs. 5-6.

This typical Upper Cretaceous form of the Tampico Embayment and Gulf Coast of North America occurs abundantly in the Maestrichtian samples of both Nekhl and Giddi. It seems to be an index fossil for this age in Egypt (see also LeRoy, 1953), which does not depend on lithofacies.

In the Giddi area this species seems to extend higher in the Danian (samples no. 839 and 840), although specimens from these samples have fewer chambers and a very slightly everted aperture.

Hypotype (U.S.N.M. P3973) from sample 6.

### **Clavulinoides asper whitei** (Cushman and Jarvis)

Plate 1, figure 38

*Clavulina aspera* Cushman var. *whitei* CUSHMAN AND JARVIS, 1932, U. S. Nat. Mus., Proc., vol. 80, art. 14, p. 19, pl. 5, figs. 6-8.

*Clavulinoides aspera* (Cushman) var. *whitei* (Cushman and Jarvis). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 39, pl. 9, figs. 31-33.

This typical uppermost Cretaceous fossil of Trinidad is

## SAID AND KENAWY

found in large numbers in a Danian sample of the Giddi section (sample no. 838).

Hypotype (U.S.N.M. P3974) from sample 838.

### **Clavulinoides cf. C. cubensis**

Cushman and Bermudez

Plate 1, figure 37

*Clavulinoides cubensis* CUSHMAN AND BERMUDEZ, 1937, Contr. Cushman Lab. Foram. Res., vol. 13, p. 2, pl. 1, figs. 5-7.

Specimens that may be referred to this species are found in sample no. 7 of the Nekhl section. The typical form of the species as described by Cushman and Bermudez from the Eocene of Havana, Cuba, is much larger and with more distinct sutures. Length of figured specimen 1 mm., about half of that recorded by Cushman and Bermudez for their Havana type.

Figured specimen (U.S.N.M. P3975) from sample 7.

### **Clavulinoides disjunctus** (Cushman)

Plate 1, figure 35

*Clavulina disjuncta* CUSHMAN, 1953, Contr. Cushman Lab. Foram. Res., vol. 9, p. 22.

*Clavulinoides disjuncta* (Cushman).—CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 40, pl. 10, figs. 12-14.

A few specimens of this species were found in sample no. 837, Giddi. Specimens are typical but seem to appear at a higher level in Egypt than in the Gulf Coast region.

Hypotypes (U.S.N.M. P3976) from sample 837.

### **Clavulinoides guayabalensis** (Cole)

Plate 1, figure 41

*Clavulina guayabalensis* COLE, 1927, Bull. Amer. Pal., vol. 14, p. 13, pl. 1, fig. 11.

*Clavulinoides guayabalensis* (Cole).—CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 127, pl. 18, figs. 10-12.

Specimens that seem to belong to this species occur in the Lower Eocene sample no. 859 of the Giddi section. Specimens differ in being slightly smaller than those from the type locality (Guayabal formation, Mexico), and also in having a more smoothly finished test. Our specimens are close to *Clavulinoides excurrens* Cushman and Renz recorded from the comparable Navet and Hospital Hill formations of Trinidad (1948).

Hypotype (U.S.N.M. P3977) from sample 859.

### **Clavulinoides trilatera** (Cushman)

Plate 1, figure 39

*Clavulinoides trilatera* CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 121, pl. 16, figs. 12-18.—CUSHMAN AND RENZ, 1946, Cushman Lab. Foram. Res., Spec. Publ. 18, p. 22, pl. 2, fig. 24.

Typical specimens of this species are recorded from the Paleocene sample no. 843, Giddi. The type comes from an exactly contemporaneous bed in the Tampico Embayment of Mexico.

Hypotype (U.S.N.M. P3978) from sample 843.

### **Clavulinoides trilatera concavus** (Cushman)

Plate 1, figure 40

*Clavulina trilatera* Cushman var. *concava* CUSHMAN, 1931, Jour. Pal., vol. 5, p. 302, pl. 34, fig. 12a-b.

*Clavulinoides trilatera* (Cushman) var. *concava* (Cushman).—CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 38, pl. 9, figs. 17-22.

Typical specimens of this variety are recorded from the Maestrichtian sample no. 6 of the Nekhl section. This species is restricted to the Taylor of North America, and its abundance, together with numerous others, at higher levels in the Old World may be referred to homotaxy.

Hypotype (U.S.N.M. P3979) from sample 6.

## Genus PSEUDOCAUDRYINELLA Cushman, 1936

### **Pseudogaudryinella compacta** ten Dam and Sigal

Plate 1, figure 44

*Pseudogaudryinella compacta* TEN DAM AND SIGAL, 1950, Contr. Cushman Found. Foram. Res., vol. 1, p. 33, pl. 2, fig. 12a-b.

A few specimens of this species occur in the Danian sample no. 7, Nekhl. They are very similar to those recorded by ten Dam and Sigal from the Dano-Montian of Algeria.

Hypotypes (U.S.N.M. P3980) from sample 7.

## Genus HETEROSTOMELLA Reuss, 1866

### **Heterostomella austinana** Cushman

Plate 1, figure 45

*Heterostomella austinana* CUSHMAN, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 53, pl. 6, figs. 1-3.—CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 141, pl. 19, figs. 18-20.—CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 41, pl. 11, figs. 2-7.

Typical specimens of this North American Taylor species were found in the Maestrichtian samples no. 6, Nekhl, and no. 833 and 835, Giddi. This species seems to appear at a higher level in Egypt than in the Gulf Coast region.

Hypotype (U.S.N.M. P3981) from sample 6.

## Family VALVULINIDAE

### Genus ARENOBULIMINA Cushman, 1927

### **Arenobulimina aegyptiaca** Said and Kenawy, new species

Plate 1, figure 42

Test elongate, slightly rounded at the base, gradually tapering, greatest breadth at the apertural end, last-formed

## FORAMINIFERA FROM SINAI

whorl making up somewhat less than one-half of the entire surface of the test; chambers rather distinct, especially in the last-formed whorl, inflated, as high as broad, usually three making up a whorl; sutures somewhat distinct, depressed; wall arenaceous with much cement and smooth; aperture a narrow loop-shaped opening at the base of the strongly convex apertural face. Length 0.9 mm.; breadth 0.5 mm.

A number of specimens of this species occur in the Danian and Paleocene samples of both Nekhl and Giddi (samples no. 7 and 8, Nekhl, and no. 842, 846, 847 and 848, Giddi).

Holotype (U.S.N.M. P3982) from sample no. 7, Danian, Nekhl.

### Genus MARSSONELLA Cushman, 1933

#### **Marssonella ellisorae** Cushman

Plate 1, figure 50

*Marssonella ellisorae* CUSHMAN, 1936, Cushman Lab. Foram. Res., Spec. Publ. 6, p. 44, pl. 4, fig. 11a-b. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 44, pl. 12, figs. 8-9.

A large number of specimens that may be referred to this species were found in sample no. 8, Nekhl, and samples no. 839, 847 and 852, Giddi. The range of this species seems to pass up into the Paleocene.

Hypotype (U.S.N.M. P3983) from sample 852.

#### **Marssonella indentata** (Cushman and Jarvis)

Plate 1, figure 47

*Marssonella indentata* (Cushman and Jarvis). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 59, pl. 6, figs. 21-22. — CUSHMAN AND RENZ, 1946, ibid., Spec. Publ. 18, p. 23, pl. 2, fig. 28. — CUSHMAN AND RENZ, 1948, ibid., Spec. Publ. 24, p. 14, pl. 3, fig. 10.

Typical specimens of this species are recorded from the Paleocene sample no. 846 and the Lower Eocene sample no. 862 of the Giddi area. This species is known from the supposedly contemporaneous Lizard Springs, Navet, and Hospital Hill formations in Trinidad.

Hypotype (U.S.N.M. P3984) from sample 862.

#### **Marssonella oxycona** (Reuss)

Plate 1, figure 48

*Marssonella oxycona* (Reuss). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 43, pl. 12, figs. 3-5.

A large number of specimens of this species were found in samples no. 7 and 11 from Nekhl and no. 833, 835, 852, 859 and 862 from Giddi. This species seems to have a wide range in Egypt. In our material we have restricted this species to specimens with parallel sides, a tapering initial end, and a flattened apertural face.

Hypotypes (U.S.N.M. P3985) from sample 852.

#### **Marssonella oxycona trinitatensis**

Cushman and Renz

Plate 1, figure 46

*Gaudryina oxycona* Reuss. — CUSHMAN AND JARVIS, 1932, Proc. U. S. Nat. Mus., vol. 80, art. 14, p. 18, pl. 5, figs. 1-2.

*Marssonella oxycona* (Reuss) var. *trinitatensis* CUSHMAN AND RENZ, 1946, Cushman Lab. Foram. Res., Spec. Publ. 18, p. 22, pl. 2, fig. 29.

*Marssonella oxyconus* (Reuss). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 39, pl. 1, figs. 3-4.

This variety, known from the Lizard Springs formation in Trinidad, has a restricted occurrence in the Sinai material. It occurs in the Paleocene samples no. 843, 844, 846, and 847, Giddi. This variety is distinguished by having a conical test, a large number of chambers, and a more depressed apertural face.

Hypotype (U.S.N.M. P3986) from sample 847.

### Genus TEXTULARIELLA Cushman, 1927

#### **Textulariella** sp.

Plate 1, figure 43

Specimens that resemble those described by d'Orbigny as "*Textularia trochus*" from the Cretaceous of the Paris Basin occur in the Giddi samples no. 837, 838, 839 and 840. Test small for the genus, conical in shape, tapering sharply; chambers distinct, increasing rapidly as added; interior labyrinthic, with the peripheral portion dividing by radiating partitions; in the adult biserial, the apertural face truncate or even concave; sutures distinct, nearly at right angles to the long axis of the test, slightly limbate; wall very finely arenaceous, smoothly finished; aperture a low opening at the middle of the base of the inner margin of the last chamber. Length 0.4 mm.; breadth 0.4 mm.

This species probably deserves a new name, but this is reserved until the original material of d'Orbigny's *Textularia trochus* is restudied.

Figured specimen (U.S.N.M. P3988) from sample 837.

### Genus DOROTHIA Plummer, 1931

#### **Dorothia bulletta** (Carsey)

Plate 1, figure 52

*Dorothia bulletta* (Carsey). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 84, pl. 9, figs. 4-9. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 46, pl. 12, figs. 21-26. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 27, pl. 2, figs. 7-8.

A large number of specimens occur throughout the succession from the Maestrichtian to the Lower Eocene in both the Nekhl and the Giddi sections (samples no. 6, 7, 8, and 9, Nekhl, and no. 837, 839, 842, 859, and 862, Giddi). It is, however, more abundant in the Maestrichtian and Danian samples.

## SAID AND KENAWY

The specimens are identical with those recorded from the Navarro group of North America. LeRoy recorded this species from the Lower Eocene of the Maqfi area in Egypt.

Hypotype (U.S.N.M. P3989) from sample 7.

### **Dorothia cf. D. conulus (Reuss)**

Plate 1, figure 54

*Dorothia conula* (Reuss). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 76, pl. 8, figs. 11-17.

*Dorothia* sp. aff. *D. conulus* (Reuss). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 27, pl. 2, figs. 18-19.

Specimens identical with those recorded by LeRoy from the "basal Eocene" are recorded from the Maestrichtian to Paleocene samples of Nekhl (no. 6, 8, and 11) and the Paleocene sample no. 842 of Giddi.

Figured specimen (U.S.N.M. P3991) from sample 6.

### **Dorothia concinna (Reuss)**

Plate 1, figure 49

*Dorothia concinna* (Reuss). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 75, pl. 8, figs. 8-10. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 44, pl. 12, figs. 10-11.

Specimens that resemble those recorded from the North American Cretaceous and the Tampico Embayment Lizard Springs formation occur in the Upper Danian samples no. 838 and 839 and the Paleocene samples no. 843, 847, and 852, Giddi. This form may be recognized by its somewhat rough exterior and its large rounded aperture that is rather contracted at the base.

Hypotype (U.S.N.M. P3990) from sample 838.

### **Dorothia pupa (Reuss)**

Plate 1, figure 53

*Dorothia pupa* (Reuss). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 78, pl. 8, figs. 20-24. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 28, pl. 1, figs. 14-15.

Specimens comparable to those recorded by Cushman from the upper Senonian of Europe and by LeRoy from the "basal Eocene" of Egypt were found in samples no. 9 and 11 from Nekhl and no. 833, 834, 835, 838, 839, 847, 848 and 852 from Giddi. This species is characterized by having a small number of distinct, inflated chambers, a slightly compressed outline in transverse view, and a smooth test.

Hypotype (U.S.N.M. P3993) from sample 839.

### **Dorothia pontoni Cushman**

Plate 1, figure 51

*Dorothia pontoni* CUSHMAN, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 55, pl. 6, fig. 8a-c. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 46, pl. 12, fig. 20.

Specimens that look exactly similar to those recorded from the Ripley formation of North America were found in small numbers in samples no. 9 and 11, Nekhl. This species seems to have a retarded appearance in Egypt, as compared with the Western Hemisphere.

This form is easily recognized by the rapid increase in the size of the chambers in the biserial stage, the conical appearance of the test, and the smoothly finished test.

Hypotype (U.S.N.M. P3992) from sample 11.

### **Dorothia retusa (Cushman)**

Plate 2, figure 2

*Dorothia retusa* (Cushman). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 85, pl. 8, figs. 33-36. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 46, pl. 13, figs. 1-4.

Specimens exactly similar to those recorded from the Velasco shale of Mexico were found in samples no. 6, 7, and 9, Nekhl, and no. 834, 842 and 859, Giddi. The range of this species in Sinai, therefore, is exactly identical with its range in the Tampico Embayment (upper Mendez to Velasco).

This form is distinguished by having a large test that is circular in cross section, inflated last chambers, distinct sutures, and a rather convex apertural face.

Hypotype (U.S.N.M. P3994) from sample 6.

### **Dorothia sinaensis Said and Kenawy, new species**

Plate 2, figure 1

Test elongate, the base, somewhat tapering, sides nearly parallel for most of their length, transverse section oval, compressed; earliest whorls with four or five chambers, later triserial, and in the adult biserial; chambers distinct, inflated, increasing very little in size as added; wall smooth, arenaceous with much cement; aperture a low, broad opening at the inner margin of the last-formed chamber. Length 0.8 mm.; breadth 0.3 mm.

This species is closely related to *Dorothia bulletta* (Carsey) and probably developed from it. It is recognized by its elongate test and by its large number of inflated chambers. This species is found in large numbers in the Lower Eocene sample no. 861, Giddi.

Holotype (U.S.N.M. P3995) from sample no. 861, Lower Eocene, Giddi.

## Genus KARRERIELLA Cushman, 1933

### **Karreriella danica (Franke)**

Plate 2, figure 4

*Gaudryina danica* FRANKE, 1927, Danmarks Geol. Unders., ser. 2, no. 46, p. 10, pl. 1, fig. 4.

*Karreriella danica* (Franke). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 122, pl. 14, figs. 20-22.

## FORAMINIFERA FROM SINAI

Specimens exactly identical to those described from the European Danian and Lower Paleocene are here recorded from the Maestrichtian sample no. 6, Nekhl. The slightly compressed test and the definite tubular neck that lies above the base on the central part of the apertural face distinguish this species. This is the oldest record of the genus *Karreriella*, a well-known marker for Tertiary strata. Although we have encountered only one specimen in the material, we have thought it advisable to include this record. A similar record of a specimen with a tubulated aperture was given by Cushman (1949), under *Dorothia*, from the Arkadelphia marl.

Hypotype (U.S.N.M. P3997) from sample 6.

### Genus HAGENOWELLA Cushman, 1933

#### **Hagenowella gibbosa** (d'Orbigny) Plate 2, figure 3

*Hagenowella gibbosa* (d'Orbigny). — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 8, p. 173, pl. 21, figs. 1-2.

Specimens exactly identical with those recorded from the Upper Cretaceous of the Paris Basin were found only in the Maestrichtian samples no. 6, Nekhl, and no. 834 and 835, Giddi. The smoothly finished test, composed of calcareous and siliceous fragments, the trochoid, more or less spherical shape and the loop-shaped aperture distinguish this species.

Hypotype (U.S.N.M. P3998) from sample 6.

### Family SILICINIDAE

#### Genus MILIAMMINA Heron-Allen and Earland, 1930

#### **Miliammina** sp. Plate 2, figure 22

Test oval in outline, very slightly compressed; chambers rather distinct, with a quinqueloculine arrangement; sutures somewhat indistinct, slightly depressed; wall smooth, siliceous; aperture terminal, with a slit-like opening extending down to the beginning of the preceding chamber. Length 0.4 mm.; breadth 0.2 mm. This species is characterized by its smooth surface and thin periphery. A few specimens of this species were found in samples no. 6, 7 and 8 of the Nekhl section.

Figured specimen (U.S.N.M. P3999) from sample 8.

### Family LAGENIDAE

The classification of the family Lagenidae is not yet settled. The system used in this paper is not claimed to be a natural one by any means, but should be regarded as a key that has proven to be utilitarian and clear cut. It is modified from the classifications of Galloway (1933), Bartenstein (1948), and Brotzen (1953).

### KEY TO LAGENID GENERA RECOGNIZED IN THIS PAPER

- I. Aperture rounded, radiate
  - i. Test compressed throughout
    - A. Test lenticular, planispiral . . . . . *Lenticulina*
    - B. Test lenticular plus curvilinear or rectilinear
      - a. Later portion trihedral . . . . . *Saracenaria*
      - b. Later portion flattened
        - 1. Coiled portion large
          - All chambers radial . . . . . *Astacolus*
          - Later chambers nearly transverse
            - Test ensiform . . . . . *Hemicristellaria*
            - Test robust . . . . . *Vaginulinopsis*
        - 2. Coiled portion small or absent
          - Test ensiform . . . . . *Vaginulina*
          - Test subtriangular . . . . . *Planularia*
      - C. Chambers equitant in later portion
        - Early chambers coiled . . . . . *Neoflabellina*
        - Early portion not coiled . . . . . *Frondicularia*
    - ii. Test rounded in adult stages
      - A. Test polythalamous
        - a. Sutures oblique at least in early portion of test
          - 1. Coiled portion large . . . . . *Marginulinopsis*
          - 2. Coiled portion small
            - Test robust . . . . . *Marginulina*
            - Test long and slender . . . . . *Dentalina*
        - b. Sutures at right angles to axis of test
          - 1. Chambers gradually enlarging, test rectilinear
            - Aperture round . . . . . *Nodosaria*
            - Aperture porous . . . . . *Chrysalagonium*
          - 2. Chambers enveloping . . . . . *Rectoglandulina*
      - B. Test monothalamous, bulbous . . . . . *Lagena*
  - II. Aperture an elongate slit
    - i. Test lenticular, planispiral . . . . . *Robulus*
    - ii. Test lenticular plus curvilinear or rectilinear, sutures oblique in later portion . . . . . *Hemirobulina*

### Genus ROBULUS Montfort, 1808

#### **Robulus isidis** (Schwager) Plate 2, figure 7

*Cristellaria isidis* SCHWAGER, 1883, Palaeontographica, vol. 30, p. 110, pl. 26(3), fig. 12a-b.

*Robulus isidis* (Schwager). — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 410, pl. 3, fig. 6. — LE ROY, 1953, Geol. Soc. Amer., Mem. 54, p. 47, pl. 9, figs. 16-17.

Specimens referred to this species are common in samples no. 6, 7 and 9, Nekhl, and no. 833, 834, 835, 838 and 840, Giddi. They correspond with the measurements and descriptions of LeRoy. Nakkady's record is very similar indeed, but that author described his species as having an umbo, which is not very evident in most of the specimens examined. Nakkady's *Robulus chambersi* may also be included in the record of this species. No justification seems evident for the separation of the two species.

## SAID AND KENAWY

Hypotypes (U.S.N.M. P4000) from sample 835.

### **Robulus münsteri** (Roemer) Plate 2, figure 12

*Robulus münsteri* (Roemer). — CUSHMAN, 1944, Contr. Cushman Lab. Foram. Res., vol. 20, p. 85, pl. 13, fig. 7. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 53, pl. 17, figs. 3-9.

A few specimens that belong to this species were found in the Upper Cretaceous samples from both sections studied. Our specimens are smaller than the American form, but agree in having the last portion slightly evolute.

Hypotype (U.S.N.M. P4001) from sample 7.

### **Robulus midwayensis carinatus** (Plummer) Plate 2, figure 6

*Cristellaria midwayensis* var. *carinata* PLUMMER, 1927, Texas Univ. Bull. 2644, p. 97, text-fig. 5.

*Robulus midwayensis* var. *carinatus* (Plummer). — CUSHMAN, 1940, Contr. Cushman Lab. Foram. Res., vol. 16, p. 55, pl. 9, fig. 13. — CUSHMAN, 1951, U. S. Geol. Survey, Prof. Paper 232, p. 13, pl. 3, figs. 18-20.

Typical specimens of this species were found in samples no. 9 and 11, Nekhl, and no. 842, 848, 852 and 859, Giddi. In Egypt this species has the same range as in the Gulf Coast area, but few specimens pass into the Lower Eocene.

Hypotypes (U.S.N.M. P4002) from sample 9.

### **Robulus pseudo-costatus** (Plummer) Plate 2, figure 13

*Cristellaria pseudo-costata* PLUMMER, 1927, Texas Univ. Bull. 2644, p. 98, pl. 7, fig. 9.

*Robulus pseudo-costatus* (Plummer). — CUSHMAN, 1951, U. S. Geol. Survey, Prof. Paper 232, p. 14, pl. 4, figs. 10-12.

Specimens that are identical with those recorded from the Paleocene of the Gulf Coast area are recorded from supposedly contemporaneous beds in Sinai (samples no. 852, Giddi, and no. 7 and 11, Nekhl). This species is easily recognized by its loose coiling and linear development in the adult stage and by the numerous radiate costae.

Hypotype (U.S.N.M. P4003) from sample 11.

### **Robulus pseudocultratus** Cole Plate 2, figure 5

*Robulus pseudocultratus* COLE, 1927, Bull. Amer. Pal., vol. 14, no. 51, p. 19, pl. 1, fig. 5. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 410, pl. 4, fig. 1.

This species, known from the Lower Eocene Guayabal formation of Mexico, is recorded from the Paleocene and Lower Eocene samples no. 843 and 861, Giddi. It may be

recognized by its small keel, flush sutures, and absence of umbo.

Hypotype (U.S.N.M. P4004) from sample 861.

### **Robulus pseudo-secans** Cushman Plate 2, figure 8

*Robulus pseudo-secans* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 53, pl. 17, figs. 11-13. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 410, pl. 4, fig. 2.

Specimens that resemble those from the Navarro formation of the Gulf Coast area are found in the Danian sample no. 837, Giddi, and in the lower Paleocene sample no. 9, Nekhl. Our specimens are slightly larger, with a pronounced umbo, limbate sutures, and a keel.

Hypotypes (U.S.N.M. P4005) from sample 837.

### **Robulus turbinatus** (Plummer) Plate 2, figure 11

*Cristellaria turbinata* PLUMMER, 1927, Texas Univ. Bull. 2644, p. 93, pl. 7, fig. 4; pl. 13, fig. 2.

*Robulus turbinatus* (Plummer). — CUSHMAN, 1940, Contr. Cushman Lab. Foram. Res., vol. 16, p. 55, pl. 9, fig. 17. — CUSHMAN, 1951, U. S. Geol. Survey, Prof. Paper 232, p. 14, pl. 4, figs. 6-9.

This species occurs in small numbers in samples no. 837 and 839, Giddi. The compressed, circular test, the sharp-keeled, ragged periphery, and the indistinct, curved sutures distinguish this species.

Hypotype (U.S.N.M. P4006) from sample 839.

### Genus **HEMICRISTELLARIA** Stache, 1864

#### **Hemicrstellaria humilis** (Reuss) Plate 2, figure 18

*Marginulina humilis* (Reuss). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 63, pl. 22, fig. 17.

Specimens that resemble those recorded from the Gulf Coast Upper Cretaceous were found in the Maestrichtian and Danian samples no. 7, Nekhl, and no. 834, Giddi. This species is distinguished from *Hemicrstellaria jarvisi* (Cushman) by the slighter compression of the test and the much less curved sutures. It is a distinct species in our material, and is very similar to that of Reuss from the European Senonian.

Hypotype (U.S.N.M., P4007) from sample 7.

#### **Hemicrstellaria tuberculata** (Plummer) Plate 2, figure 15

*Marginulina tuberculata* (Plummer). — CUSHMAN AND BERMUDEZ, 1948, Contr. Cushman Lab. Foram. Res., vol. 24, p. 69, pl. 11, fig. 5. — CUSHMAN, 1951, U. S. Geol. Survey, Prof. Paper 232, p. 17, pl. 5, figs. 11-13.

## FORAMINIFERA FROM SINAI

Typical specimens of this North American Paleocene species were found in the Paleocene samples no. 7, 8 and 11, Nekhl, and no. 855, Giddi. The elongate, compressed test with rounded periphery, the linear succession of chambers that follow the six or seven planispirally coiled early chambers, and the tuberculate sutures distinguish this species.

Hypotypes (U.S.N.M. P4008) from sample 7.

### **Hemicristellaria** sp. Plate 2, figure 14

Test somewhat compressed, elongate, earliest portion coiled, later uncoiling, periphery rounded; chambers indistinct, rather few, the earliest four to six coiled, remainder uncoiled, not inflated; sutures rather indistinct, at right angles to the axis of growth; wall smooth; aperture at the peripheral angle, radiate. Length 0.8 mm.; breadth 0.4 mm.

A few specimens of this species are recorded from the Upper Cretaceous sample no. 6, Nekhl.

Figured specimen (U.S.N.M. P4009) from sample 6.

### **Genus LENTICULINA** Lamarck, 1804

#### **Lenticulina navicula** (d'Orbigny) Plate 2, figure 9

*Cristellaria navicula* d'ORBIGNY, 1840, Mém. Soc. Géol. France, ser. 1, vol. 4, p. 27, pl. 2, figs. 19-20.

*Lenticulina navicula* (d'Orbigny). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 56, pl. 18, fig. 16. — NAKKADY, 1952, Bull. Inst. Égypte, vol. 33, p. 412, pl. 5, fig. 1.

Specimens with a tendency toward uncoiling in the later stages and with flush curved sutures are referred to this species. They were found in samples no. 834, 852 and 859, Giddi, and no. 8, Nekhl. The distribution of this species agrees well with its distribution in North and Central America.

Hypotype (U.S.N.M. P4010) from sample 3.

#### **Lenticulina rotulata** (Lamarck) Plate 2, figure 10

*Lenticulina rotulata* (Lamarck). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 56, pl. 18, fig. 19; pl. 19, figs. 1-7. — NAKKADY, 1952, Bull. Inst. Égypte, vol. 33, p. 414, pl. 3, fig. 6; pl. 5, fig. 2.

A large number of specimens that seem to belong to this species are recorded from the Upper Cretaceous samples of both sections studied (samples no. 6, Nekhl, and no. 835, Giddi). In our material we have restricted this species to specimens with a distinct umbo, limbate curved sutures, and a distinct keel.

Hypotype (U.S.N.M. P4011) from sample 6.

### **Genus SARACENARIA** Defrance, 1824

#### **Saracenaria saratogana** Howe and Wallace Plate 3, figure 2

*Saracenaria saratogana* HOWE AND WALLACE, 1932, Louisiana Dept. Cons., Bull. 2, p. 41. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 58, pl. 28, figs. 4-6.

This species, known from the upper members of the Navarro group of the Gulf Coast area, is found in Egypt in small numbers in the Danian sample no. 839, Giddi. The specimens are typical.

Hypotype (U.S.N.M. P4012) from sample 839.

#### **Saracenaria triangularis** (d'Orbigny) Plate 3, figure 1

*Cristellaria triangularis* d'ORBIGNY, 1840, Mém. Soc. Géol. France, ser. 1, vol. 4, p. 27, pl. 2, figs. 21-22.

*Saracenaria triangularis* (d'Orbigny). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 58, pl. 28, figs. 1-3. — NAKKADY, 1952, Bull. Inst. Égypte, vol. 33, p. 415, pl. 5, fig. 5.

A few typical specimens of this species were found in samples no. 6 and 8, Nekhl, and no. 833, 839 and 840, Giddi. This species has the same range in Egypt as in Europe and North America, although a few specimens may occur sporadically up to the base of the Tertiary.

Hypotype (U.S.N.M. P4013) from sample 6.

### **Genus ASTACOLUS** Montfort, 1808

#### **Astacolus calliopsis** (Reuss) Plate 2, figure 17

*Lenticulina* (*Astacolus*) *calliopsis* (Reuss). — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 286, pl. 5, figs. 120-122.

A few specimens of this European form were found in samples no. 6 and 11, Nekhl, and no. 835, Giddi. These specimens are slightly more slender and have more strongly curved sutures.

Hypotype (U.S.N.M. P4014) from sample 6.

#### **Astacolus** cf. **A. varians rectus** (Franke) Plate 2, figure 16

*Lenticulina* (*Astacolus*) cf. *varians recta* (Franke). — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 286, pl. 5, fig. 123.

A few specimens that may belong to this species were found in sample no. 833, Giddi. They differ slightly from the typical European form in having a more rounded test and more highly curved sutures.

Figured specimen (U.S.N.M. P4015) from sample 833.

## SAID AND KENAWY

### Genus *MARGINULINA* d'Orbigny, 1826

#### *Marginulina curvatura* Cushman

Plate 2, figure 20

*Marginulina curvatura* CUSHMAN, 1938, Contr. Cushman Lab. Foram. Res., vol. 14, p. 34, pl. 5, figs. 13-14. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 63, pl. 22, figs. 11-14. — CUSHMAN, 1949, U. S. Geol. Survey, Prof. Paper 221-A, p. 5, pl. 2, fig. 13.

Specimens that closely resemble those recorded from the American Arkadelphia marl were found in the Lower Eocene sample no. 859, Giddi.

Hypotype (U.S.N.M. P4016) from sample 859.

#### *Marginulina pachygaster* Gümbel

Plate 2, figure 21

*Marginulina pachygaster* Gümbel. — CUSHMAN AND PONTON, 1932, Contr. Cushman Lab. Foram. Res., vol. 8, p. 53, pl. 7, figs. 4a-b, 5. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 38, pl. 8, fig. 11.

Specimens that resemble those described by LeRoy from Egypt are recorded from a lower level in the Sinai material, in the contemporaneous samples no. 6, Nekhl, and no. 833, Giddi. These specimens may be different from Gümbel's original form described from the Eocene of Bavaria.

Hypotype (U.S.N.M. P4017) from sample 6.

### Genus *MARGINULINOPSIS* Silvestri, 1904

#### *Marginulinopsis comma* (Roemer)

Plate 2, figure 19

*Lenticulina* (*Marginulinopsis*) *comma* (Roemer). — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 288, pl. 6, fig. 135.

Specimens that resemble those recorded from the European Cretaceous were found in the Maestrichtian sample no. 6, Nekhl. Our specimens have chambers that are longer than broad in their rectilinear part, and have a slightly rougher exterior.

Hypotype (U.S.N.M. P4018) from sample 6.

#### *Marginulinopsis deserti* Said and Kenawy,

new species

Plate 2, figure 23

Test elongate, slender, early portion partly coiled, rapidly becoming uncoiled, with rather uniform diameter throughout; ventral margin in the adult convex, dorsal margin concave, circular in section; chambers distinct, elongate, inflated, particularly in the later portion, increasing gradually toward the apertural end; wall smooth, transparent; sutures distinct, depressed, at right angles to the axis

of the test; aperture radiate, protuberant, slightly toward the dorsal side. Length 0.8 mm.; breadth 0.2 mm.

This species is recognizable by its slender test and slightly inflated, elongate chambers.

Holotype (U.S.N.M. P4019) from sample no. 6, Esna shale, Maestrichtian, Nekhl.

### Genus *DENTALINA* d'Orbigny, 1826

#### *Dentalina basiplanata* Cushman

Plate 2, figure 29

*Dentalina basiplanata* CUSHMAN, 1938, Contr. Cushman Lab. Foram. Res., vol. 14, p. 38, pl. 6, figs. 6-8. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 68, pl. 24, figs. 1-6. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 417, pl. 6, fig. 3.

Specimens that closely resemble those described by Cushman from the Navarro group of the Gulf Coast area are recorded from samples no. 6, Nekhl, and no. 834, Giddi. They differ slightly in having more closely appressed chambers.

Hypotype (U.S.N.M. P4020) from sample 6.

#### *Dentalina communis* (d'Orbigny)

Plate 2, figure 26

*Nodosaria* (*Dentalina*) *communis* d'Orbigny. — d'ORBIGNY, 1840, Mém. Soc. Géol. France, vol. 4, p. 13, pl. 1, fig. 4. *Dentalina communis* (d'Orbigny). — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 308, pl. 9, figs. 228-231.

A few specimens of this species that resemble those described from the Upper Cretaceous of the Paris Basin and Germany are recorded from samples no. 6, Nekhl, and no. 837 and 859, Giddi. Specimens recorded under this name by Frizzell (1954, p. 87, pl. 9, figs. 39-40) differ in being smaller and thinner, and in having more oblique sutures. This species probably needs revision, as many forms have been lumped together with this name from deposits as old as the Jurassic.

Hypotype (U.S.N.M. P4022) from sample 6.

#### *Dentalina catenula* Reuss

Plate 2, figure 24

*Dentalina catenula* REUSS, 1860, K. Akad. Wiss. Wien, Math.-Naturw. Cl., Sitzber., vol. 40, p. 185, pl. 3, fig. 6. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 87, pl. 9, figs. 35-37.

A few specimens of this species are recorded from samples no. 833, Giddi, and no. 6, Nekhl. They are comparable with those from contemporaneous beds in the Gulf Coast area of North America.

Hypotype (U.S.N.M. P4021) from sample 6.

## FORAMINIFERA FROM SINAI

### **Dentalina gracilis (d'Orbigny)**

Plate 2, figure 25

*Nodosaria (Dentalina) gracilis* d'ORBIGNY, 1840, Mém. Soc. Géol. France, ser. 1, vol. 4, p. 14, pl. 1, fig. 5.

*Dentalina gracilis* (d'Orbigny). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 65, pl. 23, figs. 3-6.

A few specimens of this species were found in samples no. 6 and 7, Nekhl, and no. 833, Giddi. The Egyptian specimens resemble those described by d'Orbigny from the Paris Basin. Test slender, very slightly tapering; chambers increasing in length gradually as added; sutures distinct, slightly depressed, very slightly curved; wall smooth, transparent; aperture radiate. This species differs from those described from the Upper Cretaceous of the Gulf Coast area in having fewer and more elongate chambers.

Hypotype (U.S.N.M. P4028) from sample 7.

### **Dentalina ghorabi Said and Kenawy, new species**

Plate 2, figure 27

Test elongate, slightly arcuate; chambers increasing in length as added, inflated, few; initial end not pointed, curving slightly; sutures distinct, slightly oblique; wall smooth, somewhat porcelanous. Length 2 mm.; breadth 0.4 mm.

This species is distinguished by its few, inflated chambers and by its blunt initial end. A few specimens of this species were found in the Upper Cretaceous samples no. 6 and 7, Nekhl.

Holotype (U.S.N.M. P4023) from sample no. 6, Maestrichtian, Nekhl.

### **Dentalina legumen (Reuss)**

Plate 2, figure 28

*Dentalina legumen* (Reuss). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 65, pl. 23, figs. 1-2. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 419, pl. 6, fig. 6.

Typical specimens of this species, as described by Reuss, were found in the Maestrichtian sample no. 6, Nekhl. This species is distinguished, in the Egyptian material, by its slender test, oblique sutures, and somewhat protruding radiate aperture.

Hypotype (U.S.N.M. P4024) from sample 6.

### Genus NODOSARIA Lamarck, 1812

#### **Nodosaria affinis Reuss**

Plate 2, figure 30

*Nodosaria affinis* Reuss. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 70, pl. 25, figs. 8-23. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 420, pl. 6, fig. 9.

A few specimens of this distinctive species were found in sample no. 7, Nekhl. This species is widely distributed

in the Cretaceous and Lower Tertiary deposits of both Europe and North America. In Egypt it seems to have a wide range when all records of its occurrence are taken into consideration.

Hypotype (U.S.N.M. P4026) from sample 7.

### **Nodosaria limbata d'Orbigny**

Plate 2, figure 32

*Nodosaria limbata* d'ORBIGNY, 1840, Mém. Soc. Géol. France, ser. 1, vol. 4, p. 12, pl. 1, fig. 1. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 74, pl. 27, figs. 1-2.

Typical specimens of this species as recorded from Trinidad were found in sample no. 6, Nekhl. This species seems to appear at an earlier stratigraphic level in Egypt than in the Tampico Embayment, although it appears to occur in contemporaneous beds in Europe.

Hypotype (U.S.N.M. P4027) from sample 6.

### **Nodosaria paupercula Reuss**

Plate 2, figure 33

*Nodosaria paupercula* REUSS, 1845, Verstein. Böhm. Kreideform., pt. 1, p. 26, pl. 12, fig. 12. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 40, pl. 4, fig. 11.

Specimens that closely resemble those recorded by LeRoy from unit II, Farafra, Egypt, were found in sample no. 11, Nekhl. This is a costate species, distinguished by having elongate chambers and ten well-developed costae that extend across the sutures.

Hypotype (U.S.N.M. P4029) from sample 11.

### **Nodosaria "vertebralis" (Batsch) of Plummer**

Plate 2, figure 34

*Nodosaria vertebralis* (Batsch). — PLUMMER, 1927, Univ. Texas Bull. 2644, p. 88, pl. 5, fig. 10. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 423, pl. 7, fig. 4.

*Nodosaria affinis* Reuss. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 40, pl. 4, fig. 15.

Specimens that resemble those recorded by Plummer from the Midway formation of Texas and by Nakkady from the Esna shale of Egypt were found in samples no. 11, Nekhl, and no. 840, Giddi. This species probably deserves a new name, as our specimens are distinctly different from "Nautilus" *vertebralis*, described by Batsch from the Recent Adriatic, in having a stouter test, longer chambers and thicker costae. All specimens found in the material are fragmentary. We are therefore putting this record under this name, as our specimens match those of Plummer. The American Midway form resembles the Egyptian Paleocene specimens in having no tumidity of chamber contour until late maturity.

Figured specimens (U.S.N.M. P4030) from sample 11.

SAID AND KENAWY

**Nodosaria zippei** Reuss  
Plate 2, figure 31

*Nodosaria zippei* Reuss. — REUSS, 1845, Verstein. Böhm. Krieger, pt. 1, p. 25, pl. 8, figs. 1-3. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 424, pl. 7, fig. 5.

*Nodosaria cf. zippei* Reuss. — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 312, pl. 10, fig. 249.

This costate species is very close to *Nodosaria affinis*, and the two species are difficult to separate. In this paper we have restricted the use of this name to forms with more numerous sharply edged costae. A few specimens of this species are recorded from samples no. 11, Nekhl, and no. 842, Giddi.

Hypotype (U.S.N.M. P4031) from sample 11.

Genus **CHRYSALOGONIUM** Schubert, 1908

**Chrysalogonium tappanae** Said and Kenawy,  
new species  
Plate 3, figure 10

Test elongate, robust, slightly curved, initial end not tapering; chambers very slightly inflated, fusiform, slightly embracing, increasing gradually in length in the adult, but little in diameter; sutures distinct, depressed; wall ornamented by twenty to twenty-five fine, somewhat twisting, longitudinal costae; aperture terminal, consisting of a sieve-plate with numerous openings. Length 2 mm.; breadth 0.3 mm.

Several specimens of this species were found in samples no. 6 and 11, Nekhl, and no. 840, Giddi.

Holotype (U.S.N.M. P4032) from sample no. 840, upper Danian, Giddi.

Genus **RETOGLANDULINA** Loeblich and Tappan, 1955

**Rectoglandulina bulla** Said and Kenawy, new species  
Plate 3, figure 13

Test oval in outline, smooth but with faint radiate costae, tapering; chambers few, subcylindrical, distinctly embracing, the final chambers only one-quarter of the entire length of the test; suture rather indistinct, slightly depressed, slightly oblique; wall smooth, thin; aperture terminal, radiate, slightly projecting. Length 0.6 mm.; breadth 0.5 mm.

This species differs from *Rectoglandulina pygmaea* in having a thinner wall and less distinct sutures, and in having the last-formed chambers much smaller in proportion to the entire test. A few specimens of this species were found in the Paleocene sample No. 9, Nekhl.

Holotype (U.S.N.M. P4033) from sample no. 9, Paleocene, Nekhl.

**Rectoglandulina bistegia** (Olszewski)  
Plate 3, figure 11

*Pseudoglandulina bistegia* (Olszewski). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 76, pl. 27, figs. 30-32.

Specimens exactly identical with those recorded from the Paleocene Lizard Springs formation, Trinidad, were found in samples no. 838, 839 and 840, Giddi, and no. 8, Nekhl.

Hypotype (U.S.N.M. P4034) from sample 838.

**Rectoglandulina pygmaea** (Reuss)  
Plate 3, figure 12

*Glandulina pygmaea* REUSS, 1851, Haidinger's Naturwiss. Abh., vol. 4, pt. 1, p. 22, pl. 2, fig. 3.

A few specimens of this species were found in the Maestrichtian samples no. 6, Nekhl, and no. 834, Giddi. Test oval in shape, smooth, tapering; chambers few, nodosarian in arrangement, embracing, last chamber forming about two-thirds of the test; sutures distinct, very slightly depressed, slightly oblique; aperture radiate, slightly projecting.

The specimens are similar to those figured by Reuss from the German Senonian, but are different from the forms described under this name by Cushman (1946) in his Upper Cretaceous monograph.

Hypotype (U.S.N.M. P4035) from sample 834.

Genus **VAGINULINA** d'Orbigny, 1826

**Vaginulina longiformis** Said and Kenawy,  
new species  
Plate 3, figure 5a

Test elongate, compressed, periphery subacute, dorsal side straight or somewhat concave, initial end rounded; chambers numerous, distinct, much broader than high, increasing very gradually in size as added, the early chambers showing a very slight tendency toward coiling; sutures distinct, limbate; wall smooth; aperture radiate at the dorsal angle, only slightly projecting. Length 0.8 mm.; breadth 0.4 mm.

This species differs from *Vaginulina taylorana* in the form of the sutures, which are not thickened in the median portion, and in being much smaller. A few specimens of this species occur also, apart from the type level, in the Maestrichtian samples no. 6, Nekhl, and no. 833, Giddi. The latter differ slightly from the type in having less limbate sutures.

Holotype (U.S.N.M. P4036) from sample no. 847, Paleocene, Giddi.

## FORAMINIFERA FROM SINAI

### **Vaginulina misrensis** Said and Kenawy, new species Plate 3, figure 4

Test very elongate, somewhat compressed, slender, slightly tapering, usually slightly arcuate; dorsal side concave, ventral side convex, periphery rounded; chambers numerous, distinct, broader than high, increasing slightly in length and height as added; sutures very distinct, slightly oblique throughout, nearly at right angles to the periphery, flush; wall smooth; aperture radiate, slightly produced, at the dorsal angle. Length 1.2 mm.; breadth 0.4 mm.

A few specimens of this distinctive species were found only in the Maestrichtian.

Holotype (U.S.N.M. P4038) from sample no. 6, Maestrichtian, Nekhl.

### **Vaginulina** sp. Plate 3, figure 5

Test elongate, somewhat compressed, periphery rounded, dorsal side strongly concave, initial end tapering; chambers few, distinct, much broader than high, increasing gradually in size as added; aperture radiate, at the dorsal side, slightly produced. Length 0.7 mm.; breadth 0.3 mm.

A single specimen (U.S.N.M. P4040) of this species was found in sample no. 6, Nekhl.

### **Vaginulina taylorana** Cushman Plate 3, figure 3

*Vaginulina taylorana* Cushman, 1938, Contr. Cushman Lab. Foram. Res., vol. 14, p. 36, pl. 5, fig. 19. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 81, pl. 28, figs. 28-29. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 417, pl. 6, fig. 2.

A few specimens of this species are recorded from the Danian sample no. 7, Nekhl. This species is restricted in North America to strata of upper Taylor age, and its appearance in later rocks in the Eastern Hemisphere, together with others, may be due to homotaxy.

Holotype (U.S.N.M. P4039) from sample 7.

### Genus **NEOFLABELLINA** Bartenstein, 1948

#### **Neoflabellina jarvisi** (Cushman) Plate 2, figure 42

*Flabellina jarvisi* CUSHMAN, 1935, Contr. Cushman Lab. Foram. Res., vol. 11, p. 85, pl. 13, figs. 7-8. — *Palmula jarvisi* (Cushman). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 85, pl. 31, figs. 18-20.

Typical specimens of this species are known from samples no. 843-855, Giddi, and no. 7-11, Nekhl. This species is an excellent index fossil in the Egyptian material, as it occurs only in the Danian and Paleocene samples irrespective of the environmental conditions of deposition. The vertical distribution of this species coincides exactly with its distribution in Trinidad, where it is known from the

Lizard Springs formation, and in the Velasco shale of Mexico.

This species is closely related to *Neoflabellina rugosa*, but differs in having a narrow test, fewer coiled chambers, and higher sutures with irregularly shaped loops. This record of the species extends the range of this genus as given by Bartenstein (1949) to the Paleocene.

Holotype (U.S.N.M. P4041) from sample 11.

#### **Neoflabellina rugosa** (d'Orbigny) Plate 2, figure 43

*Flabellina rugosa* d'ORBIGNY, 1840, Mém. Soc. Géol. France, ser. 1, vol. 4, p. 23, pl. 2, figs. 4-5, 7.

*Palmula rugosa* (d'Orbigny). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 83, pl. 31, figs. 9-17. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 426, pl. 8, fig. 2.

This is one of the best index fossils in the Egyptian material that seem to occur in all areas irrespective of environmental conditions. It occurs in samples no. 6 and 7, Nekhl, and in the contemporaneous samples no. 833-842, Giddi. The distribution of this species in Egypt coincides exactly with its distribution in Europe and the Gulf Coast area. As far as we can gather from Nakkady's few notes on this species, its distribution in both the Durba and the Danili sections also agrees well with its distribution in the material studied in the present work.

Holotype (U.S.N.M. P4042) from sample 6.

#### **Neoflabellina semireticulata** (Cushman and Jarvis) Plate 2, figure 40

*Palmula semireticulata* (Cushman and Jarvis). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 85, pl. 31, figs. 7-8.

A very few specimens of this species were found in the Maestrichtian sample no. 835, Giddi. This species is distinguished by having a small and thick test with irregular reticulate ornamentation. It has a sporadic distribution in the Egyptian material.

Holotype (U.S.N.M. P4043) from sample 835.

#### **Neoflabellina suturalis** (Cushman) Plate 2, figure 41

*Flabellina suturalis* CUSHMAN, 1935, Contr. Cushman Lab. Foram. Res., vol. 11, p. 86, pl. 13, figs. 9-18.

*Palmula suturalis* (Cushman). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 43, pl. 3, fig. 4.

Typical specimens of this species, as described by Cushman and as figured by LeRoy, were found in the contemporaneous samples no. 837, Giddi, and no. 7, Nekhl. They seem to appear at a higher level in Sinai than in the Western Desert, although the exact age of the material studied is not obvious from LeRoy's work, because LeRoy did not discuss the distribution of the species of *Globotruncana* and *Truncorotalia*.

## SAID AND KENAWY

Hypotype (U.S.N.M. P4044) from sample 7.

### Genus **FRONDICULARIA** Defrance, 1826

#### **Frondicularia cordata** Roemer Plate 2, figure 39

*Frondicularia cordata* ROEMER, 1841, Verstein. Norddeutschen Kreidegeb., p. 96, pl. 15, fig. 8. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 98, pl. 12, figs. 25-26.

A few specimens of this distinctive species of the upper Senonian of Europe were noted in the Danian sample no. 7, Nekhl. This species seems to appear at a later time in the Eastern Hemisphere than in the Western.

Hypotype (U.S.N.M. P4045) from sample 7.

#### **Frondicularia** cf. **F. clarki** Bagg Plate 2, figure 37

*Frondicularia clarki* Bagg. — BAGG, 1898, U. S. Geol. Survey, Bull. 88, p. 48, pl. 3, fig. 4. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 98, pl. 12, figs. 21-24.

A few specimens that may belong to this species are recorded from the Egyptian Paleocene samples no. 11, Nekhl, and no. 842, Giddi. The test is elliptical, somewhat thick in the middle. As recorded by Frizzell, this is a typical Navarro species, and our record may need revision.

Figured specimen (U.S.N.M. P4047) from sample 11.

#### **Frondicularia frankei** Cushman Plate 2, figure 35

*Frondicularia frankei* Cushman. — CUSHMAN AND DEADERICK, 1944, Jour. Pal., vol. 18, p. 335, pl. 52, fig. 10. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 89, pl. 35, figs. 14-16; pl. 36, fig. 1.

A few typical specimens of this Gulf Coast Navarro and Taylor species are recorded from the Maestrichtian sample no. 835, Giddi. The ornamented walls of the chambers with strongly raised, short, stout and vertical costae, distinguish this species.

Hypotype (U.S.N.M. P4046) from sample 835.

#### **Frondicularia goldfussi** Reuss Plate 2, figure 36

*Frondicularia goldfussi* Reuss. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 87, pl. 34, figs. 18-20; pl. 35, figs. 1-2. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 428, pl. 8, fig. 3.

A few specimens of this species were found in the Maestrichtian samples no. 834, Giddi, and no. 8, Nekhl.

Hypotype (U.S.N.M. P4048) from sample 8.

### **Frondicularia linearis** Franke Plate 2, figure 38

*Frondicularia linearis* Franke. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 88, pl. 35, figs. 8-10. — NAKKADY, 1952, Bull. Inst. Egypte, vol. 33, p. 429, pl. 8, fig. 6.

This species seems to be restricted to the Danian samples no. 7, Nekhl, and no. 837, Giddi. It is a characteristic species that is distinguished by a slender and compressed test, which is ornamented with a few longitudinal costae.

Hypotype (U.S.N.M. P4049) from sample 7.

### Genus **LAGENA** Walker and Boys, 1784

#### **Lagena apiculata** Reuss Plate 3, figure 8

*Lagena apiculata* Reuss. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 94, pl. 39, fig. 23.

*Lagena apiculata apiculata* Reuss. — BARTENSTEIN AND BRAND, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 316.

A number of specimens of this species were found in samples no. 6, Nekhl, and no. 833, Giddi. Our specimens fit the description given by Cushman, but are slightly larger.

Hypotype (U.S.N.M. P4050) from sample 6.

#### **Lagena** cf. **L. globosa** (Montagu) Plate 3, figure 7

*Lagena* cf. *L. globosa* (Montagu). — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 102, pl. 14, fig. 7.

Specimens that may belong to this species are found in samples no. 6, Nekhl, and no. 833, 834, 835, 837 and 839, Giddi. There are a number of variable globose and smooth forms that are included here; the majority are spherical with radiate apertures.

Figured specimen (U.S.N.M. P4051) from sample 6.

#### **Lagena hispida** Reuss Plate 3, figure 9

*Lagena hispida* Reuss. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 93, pl. 39, fig. 13. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 102, pl. 14, fig. 8.

Typical specimens of this hispid, spinose species with an elongate neck are known from the Danian samples no. 7 and 11, Nekhl, and no. 838, Giddi.

Hypotype (U.S.N.M. P4052) from sample 838.

#### **Lagena sulcata** (Walker and Jacob) Plate 3, figure 6

*Lagena sulcata* (Walker and Jacob). — CUSHMAN, 1929, Contr. Cushman Lab. Foram. Res., vol. 5, p. 70, pl. 11, fig. 5. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 37, pl. 7, fig. 28.

## FORAMINIFERA FROM SINAI

A few specimens of this species were found in samples no. 6, Nekhl, and no. 835, Giddi. These specimens correspond well with LeRoy's descriptions and figures.

Hypotype (U.S.N.M. P4053) from sample 6.

### Genus LAGENONODOSARIA Silvestri, 1900

**Lagenonodosaria sinaensis** Said and Kenawy,  
new species  
Plate 3, figure 15

Test small, elongate, of about equal diameter throughout except at the gradually tapering initial end; chambers few, distinct, increasing in length as added, partially embracing, very slightly inflated in the adult, not inflated in the earlier stages; sutures distinct, slightly depressed; wall ornamented by eight costae running uninterruptedly from the initial end to the aperture, which is terminal, small, projecting, rounded and feebly radiate. Length 0.5 mm.; breadth 0.2 mm.

Several specimens of this small and distinct species were found in the Paleocene samples of Nekhl.

Holotype (U.S.N.M. P4054) from sample no. 8, Paleocene, Nekhl.

### Family POLYMORPHINIDAE

#### Genus EOGUTTULINA Cushman and Ozawa, 1930

**Eoguttulina anglica** Cushman and Ozawa  
Plate 3, figure 14

*Eoguttulina anglica* CUSHMAN AND OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 16, pl. 1, fig. 3a-c.

Several typical specimens of this European Upper Cretaceous species are recorded from the Danian samples no. 837, 838, 839 and 840, Giddi. This species has recently been reported from North America (Frizzell, 1954).

Hypotype (U.S.N.M. P4055) from sample 837.

#### Genus GUTTULINA d'Orbigny, 1839

**Guttulina adhaerens** (Olszewski)  
Plate 3, figure 19

*Guttulina adhaerens* (Olszewski). — CUSHMAN AND OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 36, pl. 1, fig. 9a-c; pl. 6, fig. 7a-b. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 96, pl. 40, figs. 8-10.

A few typical specimens of this species were found in sample no. 11, Nekhl. This species is recorded from a comparable horizon in Trinidad.

Hypotype (U.S.N.M. P4056) from sample 11.

#### **Guttulina trigonula** (Reuss)

Plate 3, figure 16

*Polymorphina trigonula* REUSS, 1845, Verstein. Böhm. Kreideform., pt. 1, p. 40, pl. 13, fig. 84.

*Guttulina trigonula* (Reuss). — CUSHMAN AND OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 28, pl. 4, fig. 2a-c. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 95, pl. 40, figs. 6-7.

Several typical specimens of this species were found in the Paleocene sample no. 842, Giddi.

Hypotype (U.S.N.M. P4057) from sample 842.

#### Genus GLOBULINA d'Orbigny, 1839

**Globulina lacrima** (Reuss)  
Plate 3, figures 17-18

*Globulina lacrima* (Reuss). — REUSS, 1851, Haidinger's Naturwiss. Abh., vol. 4, p. 43, pl. 5, fig. 9. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 96, pl. 40, figs. 11-12.

Numerous specimens of this species are recorded from the Maestrichtian sample no. 6, Nekhl. Specimens that are similar but with a more depressed test were found in the Paleocene sample no. 852, Giddi. These may belong to a different species.

Hypotype (U.S.N.M. P4058) from sample 852.

#### Genus PYRULINOIDES Marie, 1941

**Pyrulinoides acuminatus** (d'Orbigny)  
Plate 3, figure 21

*Pyrulinoides acuminata* (d'Orbigny). — MARIE, 1941, Mém. Mus. Nat. Hist. Nat., vol. 12, pl. 170, pl. 24, figs. 243-246.

A few typical specimens of this European Upper Cretaceous species were found in the Maestrichtian samples no. 833, Giddi, and no. 6, Nekhl.

Hypotype (U.S.N.M. P4059) from sample 833.

#### Genus GLANDULINA d'Orbigny, 1839

**Glandulina antiqua** Said and Kenawy, new species  
Plate 3, figure 22

Test medium-sized, circular in apertural view, thickest near top, initial end pointed; chambers biserial in early part, later uniserial, strongly embracing; sutures straight, parallel and horizontal; chambers inflated and spherical, embracing so that they appear small externally; wall smooth and thick; aperture terminal, projecting, radiate. Length 0.5 mm.; breadth 0.3 mm.

This species is closely related to *Glandulina laevigata*, but differs in having a more slender and tapering initial end and in having smaller chambers. This species occurs in samples no. 7 and 8, Nekhl.

## SAID AND KENAWY

Holotype (U.S.N.M. P4060) from sample no. 7, Danian, Nekhl.

### **Glandulina laevigata** (d'Orbigny) Plate 3, figure 30

*Nodosaria (Glandulina) laevigata* d'Orbigny, 1828, Ann. Sci. Nat., vol. 7, p. 252, pl. 10, figs. 1-3.

A few specimens of this species were found in all Paleocene samples from Nekhl. These specimens clearly show the earlier biserial stage. Our specimens are typical except for being larger in size with a thicker wall and a more protuberant aperture.

Hypotype (U.S.N.M. P4061) from sample 11.

### Genus RAMULINA Jones, 1875

#### **Ramulina navarroana** Cushman Plate 3, figure 23

*Ramulina navarroana* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 99, pl. 43, figs. 1-2. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 46, pl. 8, fig. 24.

Typical specimens of this American Navarro species are recorded from sample no. 835, Giddi.

Hypotype (U.S.N.M. P4062) from sample 835.

### Genus ENANTIOMORPHINA Marie, 1941

#### **Enantiomorphina lemoinei conica** Marie Plate 3, figure 26

*Enantiomorphina lemoinei* Marie var. *conica* MARIE, 1941, Mém. Mus. Nat. Hist. Nat., vol. 12, p. 146, pl. 18, fig. 198a-e.

A few typical specimens of this variety were found in sample no. 7, Nekhl. These specimens agree well with Marie's description, measurements and figures of the form from the Upper Cretaceous of Europe.

Hypotype (U.S.N.M. P4063) from sample 7.

#### **Enantiomorphina lemoinei inflata** Marie Plate 3, figure 24

*Enantiomorphina lemoinei* Marie var. *inflata* MARIE, 1941, Mém. Mus. Nat. Hist. Nat., vol. 12, p. 147, pl. 18, figs. 199a-g, 200a-e.

A few specimens that seem to belong to this variety are recorded from the Danian sample no. 7, Nekhl.

Hypotype (U.S.N.M. P4064) from sample 7.

### Genus ENANTIOVAGINULINA Marie, 1941

#### **Enantiovaginulina recta** (d'Orbigny) Plate 3, figure 25

*Enantiovaginulina recta* (d'Orbigny). — MARIE, 1941, Mém. Mus. Nat. Hist. Nat., vol. 12, p. 161, pl. 21, fig. 235a-c.

A few specimens of this species were found in sample no. 7, Nekhl. Our specimens agree with the descriptions and measurements of those recorded from the European Upper Cretaceous.

Hypotype (U.S.N.M. P4065) from sample 7.

## Family HETEROHELICIDAE

### Genus BOLIVINOPSIS Yakovlev, 1891

#### **Bolivinopsis clotho** (Grzybowski) Plate 3, figure 20

*Bolivinopsis clotho* (Grzybowski). — CUSHMAN AND JARVIS, 1928, Contr. Cushman Lab. Foram. Res., vol. 4, p. 101, pl. 14, figs. 13-14.

Specimens that exactly resemble those recorded by Cushman and Jarvis from the Paleocene of Trinidad were found in small numbers in the Sinai Paleocene sample no. 9, Nekhl. LeRoy's record of this species is different from ours and should probably be assigned to another species. The test of this species is smooth and does not react with HCl.

Hypotype (U.S.N.M. P4066) from sample 9.

### **Bolivinopsis minuta** Said and Kenawy, new species

#### Plate 3, figure 27

Test elongate, slender, compressed, thickest along the median line, the early portion closely coiled, planispiral, with a single coil, later chambers biserial, of uniform size and shape, the sides of the test parallel; chambers about ten in the adult, often slightly broader than high; sutures distinct, extending obliquely backward; wall smooth and polished, finely perforate. Length 0.25 mm.; breadth 0.1 mm.

This species differs from *Bolivinopsis rosula* in being smaller in size, in having fewer chambers in the biserial stage, and in having the chambers broader than high.

Holotype (U.S.N.M. P4067) from sample no. 6, Maestrichtian, Nekhl.

### **Bolivinopsis rosula** (Ehrenberg)

#### Plate 3, figure 28

*Bolivinopsis rosula* (Ehrenberg). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 101, pl. 44, figs. 4-8.

A few specimens of this species are recorded from the Paleocene sample no. 855, Giddi. The specimens are typical and resemble those described from the type locality.

Hypotype (U.S.N.M. P4068) from sample 855.

## FORAMINIFERA FROM SINAI

### Genus GÜMBELINA Egger, 1900

#### **Gümbelina globulosa** (Ehrenberg)

Plate 3, figure 29

*Gümbelina globulosa* (Ehrenberg). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 105, pl. 45, figs. 9-15.

A flood of specimens of this species occurs in samples no. 6, Nekhl, and no. 833, 834 and 835, Giddi. This species occurs also in smaller numbers in the Danian and Paleocene samples of both sections.

Hypotype (U.S.N.M. P4069) from sample 6.

#### **Gümbelina reussi** Cushman

Plate 3, figure 32

*Gümbelina reussi* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 104, pl. 44, figs. 18-19. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 34, pl. 8, fig. 14.

Typical specimens of this species occur in small numbers in all Maestrichtian samples of both sections.

Hypotype (U.S.N.M. P4071) from sample 833.

#### **Gümbelina plummerae** Loetterle

Plate 3, figure 33

*Gümbelina plummerae* LOETTERLE, 1937, Nebraska Geol. Survey Bull., ser. 2, no. 12, p. 33, pl. 5, figs. 1-2. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 104, pl. 45, figs. 1-3.

This characteristic species occurs in large numbers in all the Maestrichtian samples of both sections. This is a striated species, which differs in its later stages from the characters of the genus *Gümbelina* as represented by its genotype.

Hypotype (U.S.N.M. P4070) from sample 6.

#### **Gümbelina ultimatumida** White

Plate 3, figure 31

*Gümbelina ultimatumida* WHITE, 1929, Jour. Pal., vol. 3, p. 39, pl. 4, fig. 13. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 107, pl. 46, figs. 6-7.

A large number of specimens that belong to this species were found in all Maestrichtian samples of both the Nekhl and the Giddi sections. This species occurs also in the Danian samples in small numbers. This is a feebly striate species, in which the striae are not continuous but have the form of interrupted dots. As far as the Egyptian material shows, no accessory apertures are present. This species therefore belongs to the genus *Gümbelina*.

Hypotype (U.S.N.M. P4072) from sample 835.

### Genus PSEUDOGÜMBELINA Bronnimann and Brown, 1953

#### **Pseudogümbelina striata** (Ehrenberg)

Plate 3, figure 37

*Gümbelina striata* (Ehrenberg). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 104, pl. 45, figs. 4-5. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 34, pl. 6, figs. 6-7.

A large number of specimens that belong to this species were found in all the Maestrichtian samples. There are a number of specimens that clearly show the flaps described by Bronnimann and Brown (1953, Contr. Cushman Found. Foram. Res., vol. 4, pp. 150-156), but there are others that have them poorly developed and almost absent.

Hypotype (U.S.N.M. P4074) from sample 6.

#### **Pseudogümbelina excolata** (Cushman)

Plate 3, figure 36

*Pseudogümbelina excolata* (Cushman). — BRONNIMANN AND BROWN, 1953, Contr. Cushman Found. Foram. Res., vol. 4, p. 153, text-figs. 1-4.

Specimens that belong to this species are common in all the Maestrichtian samples of the sections studied. This species occurs also in small numbers in the Danian samples. Our specimens clearly show the chamber flaps that distinguish the genus. This species is known from the Upper Cretaceous of Texas and Arkansas, the Lantern marl of Trinidad, and the Upper Cretaceous of Israel.

Hypotype (U.S.N.M. P4073) from sample 835.

### Genus RECTOGÜMBELINA Cushman, 1932

#### **Rectogümbelina cretacea** Cushman

Plate 3, figure 34

*Rectogümbelina cretacea* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 110, pl. 47, figs. 2-3.

Typical specimens of this species were found in sample no. 7, Nekhl.

Hypotype (U.S.N.M. P4075) from sample 7.

#### **Rectogümbelina longa** Said and Kenawy, new species

Plate 3, figure 35

Test minute, consisting of two unequal portions, the early portion making up about one-quarter of the length and consisting of several pairs of somewhat globular chambers, the adult stage uniserial, formed usually by four subglobular chambers, slightly overlapping, the apertural end extended out into a slightly tapering neck; sutures distinct, depressed; wall smooth, translucent; aperture circular, at the end of a slightly projecting neck. Length 0.28 mm.; breadth 0.5 mm.

## SAID AND KENAWY

This species occurs abundantly in the Danian sample no. 7, Nekhl. The holotype (U.S.N.M. P4076) is from this sample.

### Genus *PLANOGLOBULINA* Cushman, 1927

#### *Planoglobulina acervulinoides* (Egger)

Plate 3, figure 45

*Planoglobulina acervulinoides* (Egger). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 111, pl. 47, figs. 12-15.

Numerous specimens of this species were found in all Maestrichtian samples of both Nekhl and Giddi.

Hypotype (U.S.N.M. P4077) from sample 6.

### Genus *VENTILABRELLA* Cushman, 1928

#### *Ventilabrella eggeri* Cushman

Plate 3, figure 38

*Ventilabrella eggeri* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 111, pl. 47, figs. 17-19. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 54, pl. 6, figs. 24-25.

This species was found in large numbers in all Maestrichtian samples of both Nekhl and Giddi.

Hypotype (U.S.N.M. P4078) from sample 6.

#### *Ventilabrella eggeri glabrata* Cushman

Plate 3, figure 46

*Ventilabrella eggeri* Cushman var. *glabrata* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 111, pl. 47, figs. 20-22.

This variety occurs with the typical form in large numbers in all Maestrichtian samples of both sections studied.

Hypotype (U.S.N.M. P4079) from sample 6.

### Genus *BOLIVINOIDES* Cushman, 1927

#### *Bolivinoides curtus* Reiss

Plate 3, figure 43

*Bolivinoides curta* REISS, 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 158, pl. 30, figs. 15-16.

A few specimens of this species were found in the lower-most samples of the Paleocene of Giddi.

Hypotypes (U.S.N.M. P4080) from sample 842.

#### *Bolivinoides draco draco* (Marsson)

Plate 3, figure 41

*Bolivinoides draco draco* (Marsson). — HILTERMANN AND KOCH, 1950, Geol. Jahrb., vol. 64, p. 598, text-fig. 1, nos. 72a-c, 73a-b; text-figs. 2-4, nos. 52-54, 58-60; text-fig. 5, nos. 53, 69, 70. — REISS, 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 155, pl. 29, figs. 1-3.

Typical specimens of this species were found in the upper Maestrichtian samples no. 6, Nekhl, and no. 833, 834,

and 835, Giddi. This species seems to be an excellent index fossil for this horizon. It has a short stratigraphic range and wide distribution irrespective of environmental conditions. This is the first record of this species in Egypt.

Hypotypes (U.S.N.M. P4081) from sample 6.

#### *Bolivinoides draco miliaris* Hiltermann and Koch

Plate 3, figure 40

*Bolivinoides draco miliaris* HILTERMANN AND KOCH, 1950, Geol. Jahrb., vol. 64, p. 604, text-figs. 2-4, nos. 26, 32-34, 39-41, 46-48; text-fig. 5, no. 39a-c. — REISS, 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 155, pl. 28, figs. 9-12, 14.

Typical specimens of this species were found in the Maestrichtian samples no. 21, Nekhl, and no. 833 and 834, Giddi. They seem to be absent from the topmost Maestrichtian samples of both sections. The distribution of this species in Egypt is similar to its distribution in Israel.

Hypotypes (U.S.N.M. P4082) from sample 833.

#### *Bolivinoides delicatulus* Cushman

Plate 3, figure 44

*Bolivinoides decorata* (Jones) var. *delicatula* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 113, pl. 48, figs. 10-14.

*Bolivinoides delicatula* Cushman. — REISS, 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 157, pl. 31, figs. 1-4.

Typical specimens of this species are known from the Danian samples of both the Nekhl and the Giddi sections. This species is an excellent index fossil for the Danian. It is associated, when ecologic conditions permit, with a flood of representatives of the family Globigerinidae. The upper limit of the Danian in the Giddi section is drawn on the basis of the distribution of this species.

Hypotypes (U.S.N.M. P4083) from sample 837.

#### *Bolivinoides draco dorreenei* Finlay

Plate 3, figure 42

*Bolivinoides draco dorreenei* Finlay. — REISS, 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 155, pl. 29, figs. 4-7.

Typical specimens of this species were found in all Maestrichtian samples; it is an excellent marker for this horizon.

Hypotype (U.S.N.M. P4084) from sample 6.

#### *Bolivinoides semireticulatus* (LeRoy)

Plate 3, figure 48

*Bolivina semireticulata* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 20, pl. 8, fig. 26.

Typical specimens of this species occur in sample no. 859, Giddi. This species was originally described from the Lower Eocene of Farafra. It is similar in many characters

## FORAMINIFERA FROM SINAI

to *Bolivinoides trinitatensis* Cushman and Jarvis, except for its straight and smooth sutures.

Hypotype (U.S.N.M. P4085) from sample 859.

**Bolivinoides cf. B. trinitatensis** Cushman and Jarvis  
Plate 3, figure 47

*Bolivinoides trinitatensis* Cushman and Jarvis. — CUSHMAN, 1946,  
U. S. Geol. Survey, Prof. Paper 206, p. 114, pl. 48, fig. 17.

This Paleocene species, known from the Lizard Springs formation of Trinidad, is recorded from the Danian samples of both Nekhl and Giddi and extends into the lower Paleocene, occurring in no. 8, Nekhl. Our specimens have a more or less keeled test, which is thick in its middle portion. This species differs from *Bolivinoides paleocenicus* (Brotzen) in having smoothly curved sutures.

Figured specimen (U.S.N.M. P4086) from sample 8.

### Genus BOLIVINITA Cushman, 1927

**Bolivinita bandyi** Said and Kenawy, new species  
Plate 3, figure 49

Test small, about twice as long as broad, gradually broadening from the acute initial end of the point of greatest breadth, which is slightly below the final chambers, thence tapering to the apertural end; periphery truncate or slightly convex, strongly serrate in front view, in transverse section rectangular, broader faces flattened or concave; chambers biserial in five pairs, distinct, increasing gradually in size as added, earlier chambers flattened and compressed, later chambers greatly increasing in thickness; sutures distinct, straight but slightly oblique; wall smooth; aperture broad, oval in transverse section, with a slightly raised border. Length 0.25 mm.; breadth 0.17 mm.; thickness 0.10 mm.

This species occurs in small numbers in all the Danian samples of both sections. It differs from *Bolivinita costifera* Cushman in having more spiny projections along the chambers and in having a smaller and more tapering test.

Holotype (U.S.N.M. P4087) from sample no. 838, Danian, Giddi.

### Genus EOUVIGERINA Cushman, 1926

**Eouvigerina aegyptiaca** Nakkady  
Plate 4, figure 2

*Eouvigerina aegyptiaca* NAKKADY, 1950, Jour. Pal., vol. 24, p. 686, pl. 89, fig. 18.

Numerous typical specimens of this species were found in all the Maestrichtian samples of both Nekhl and Giddi. Nakkady's figure and description do not indicate the shape of this species in side view. Our specimens have a somewhat compressed and elongate test.

Hypotypes (U.S.N.M. P4088) from sample 835.

**Eouvigerina hofkeri** Said and Kenawy, new species  
Plate 3, figure 50

Test elongate, slender, tapering, greatest width formed by the last two chambers; earliest chambers obscure, the test for the most part made up of biserial chambers, those of the adult becoming triserial and more isolated from one another; chambers inflated, round in transverse section; sutures distinct, much depressed; wall smooth, porcelanous; aperture rounded, terminal, on a neck. Length 0.25 mm.; breadth 0.20 mm.

This species is very close to *Eouvigerina aegyptiaca* except for its more inflated and attenuate chambers and its smaller and more rounded test. It occurs in the Danian samples of both Giddi and Nekhl.

Holotype (U.S.N.M. P4089) from sample no. 7, Danian, Nekhl.

### Genus ZEAUVIGERINA Finlay, 1939

**Zeauvigerina aegyptiaca** Said and Kenawy,  
new species  
Plate 4, figure 1

Test small, about twice as long as broad, gradually broadening from the subacute initial end to the point of greatest breadth, which is slightly above the middle, after which the sides become parallel; periphery slightly rounded, in transverse section somewhat rectangular; biserial throughout; chambers broader than high, indistinct; sutures indistinct, slightly depressed; wall smooth; aperture rounded, at the end of a short but distinct neck, with a weakly developed lip. Length 0.3 mm.; breadth 0.2 mm.

This species was found in samples no. 21, 8 and 9, Nekhl, and no. 835, Giddi. It is a distinctive species, which is here assigned to the genus *Zeauvigerina*, although this genus was recently suppressed by Loeblich (1951) after a study of the genotype of *Eouvigerina*. *Zeauvigerina* deserves to be re-established, to include forms that are completely biserial and with the aperture on a neck. The discovery of the present species in the material examined extends the range of this genus into the Cretaceous.

Holotype (U.S.N.M. P4091) from sample 8.

### Genus PSEUDOOUVIGERINA Cushman, 1927

**Pseudouvigerina sinaensis** Said and Kenawy,  
new species  
Plate 4, figure 3

Test minute, twice as long as broad; chambers comparatively few, the last three making up the larger part of the test, in end view triangular; periphery sharp; sutures distinct, depressed; surface minutely roughened; aperture circular, with a short cylindrical neck. Length 0.4 mm.; breadth 0.25 mm.

This species is easily distinguished by its triangular,

minute, and somewhat roughened test. It is restricted in occurrence, occurring in large numbers in all the upper Maestrichtian samples of both sections and in the Danian sample no. 837, Giddi.

Holotype (U.S.N.M. P4092) from sample no. 835, Maestrichtian, Giddi.

Genus ORTHOMORPHINA Stainforth, 1952

**Orthomorphina rohri** (Cushman and Stainforth)

Plate 4, figure 4

*Nodogenerina rohri* CUSHMAN AND STAINFORTH, 1945, Cushman  
Lab. Foram. Res., Spec. Publ. 14, p. 39, pl. 5, fig. 26.

A few typical specimens of this species, originally described from the Oligocene and recorded from the Eocene formations of Trinidad, were found in the Egyptian material, in the Danian sample no. 7, Nekhl. This species clearly shows the characters of the genus *Orthomorphina* as described by Stainforth (1952b). The small number of irregularly arranged chambers and the simple terminal aperture distinguish this species.

Hypotype (U.S.N.M. P4093) from sample 7.

**Orthomorphina** sp.

Plate 4, figure 5

Test uniserial, slightly curved, smooth; chambers slightly inflated; sutures distinct; early chambers somewhat globular, later chambers tending to become lengthened, but chambers arranged more or less regularly; aperture terminal, rounded, a simple orifice. Length 0.5 mm.; breadth 0.15 mm.

Only one specimen of this species (figured specimen, U.S.N.M. P4094) was found, in the Maestrichtian sample no. 834, Giddi.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

**Buliminella cushmani** Sandidge

Plate 4, figure 7

*Buliminella cushmani* Sandidge. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 119, pl. 50, fig. 15. — LE ROY, 1953, Geol. Soc. Amer., Mem. 54, p. 22, pl. 8, fig. 12.

This typical Upper Cretaceous species, recorded from both Europe and North America, is found in large numbers in all the Maestrichtian samples of both sections.

Hypotype (U.S.N.M. P4097) from sample 835.

**Buliminella carseyae** Plummer

Plate 4, figure 8

*Buliminella carseyae* Plummer. — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 58, pl. 15, fig. 8.

This species occurs in small numbers in sample no. 9, Nekhl. It is widespread in the Upper Cretaceous of both

Europe and America, but in Egypt it appears in the Paleocene. Our specimens may differ from *Buliminella hofkeri* Brotzen (regarded as a synonym of *Buliminella carseyae* by Cushman and Parker), and from the North American records of *Buliminella carseyae*, in being longer in relation to breadth.

Length of figured specimen (U.S.N.M. P4095, from sample 9) 0.38 mm.; breadth 0.30 mm.

**Buliminella fabilis** Cushman and Parker

Plate 4, figure 9

*Buliminella fabilis* Cushman and Parker. — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 59, pl. 15, fig. 13.

Numerous specimens that seem to belong to this species were found in all the Danian samples of both sections. The Egyptian specimens differ slightly in having more chambers. This is a Taylor species as recorded from the Gulf Coast area, but seems to be restricted to the Danian in Egypt.

Hypotypes (U.S.N.M. P4096) from sample 837.

**Buliminella laevis** (Beissel)

Plate 4, figure 6

*Buliminella laevis* (Beissel). — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 57, pl. 15, fig. 6.

A large number of specimens of this species were found in all the upper Maestrichtian samples of both sections. Most of the specimens are thick-walled, polished, and large for the genus. They resemble those recorded by numerous authors from the Senonian of northern Europe.

Hypotype (U.S.N.M. P4098) from sample 6.

Genus BULIMINA d'Orbigny, 1826

**Bulimina arkadelphiana midwayensis**

Cushman and Parker

Plate 4, figure 11

*Bulimina arkadelphiana midwayensis* Cushman and Parker. — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 92, pl. 21, figs. 24-25.

A few specimens of this Gulf Coast Paleocene form were found in the Paleocene sample no. 11, Nekhl. The spines that project on the earlier chambers are less developed than in the typical form.

Hypotype (U.S.N.M. P4099) from sample 11.

**Bulimina kickapooensis** Cole

Plate 4, figure 12

*Bulimina kickapooensis* Cole. — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 81, pl. 19, figs. 19-20.

Typical specimens of this Upper Cretaceous species were

## FORAMINIFERA FROM SINAI

seen in all the Upper Maestrichtian samples of both sections.

Hypotype (U.S.N.M. P4100) from sample 834.

### **Bulimina prolixa** Cushman and Parker Plate 4, figure 13

*Bulimina prolixa* Cushman and Parker. — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 84, pl. 20, figs. 7-8.

Specimens that correspond to the descriptions and measurements of this species as recorded from the American Upper Cretaceous were found in small numbers in the Paleocene and Lower Eocene of Giddi (samples no. 852 and 859). There is one record of this species in the Eocene of Alabama.

Hypotypes (U.S.N.M. P4102) from sample 859.

### **Bulimina reussi** Morrow Plate 4, figure 15

*Bulimina reussi* Morrow. — CUSHMAN AND PARKER, 1947, U. S. Geol. Survey, Prof. Paper 210-D, p. 84, pl. 19, fig. 31; pl. 20, figs. 1-5.

Numerous specimens that seem to belong to this species were found in sample no. 11, Nekhl. This species, known from many Upper Cretaceous localities and also from the Velasco shale of Mexico, is recorded in Egypt from the Paleocene. It is possible that Nakkady's record of *Bulimina murchisoniana* d'Orbigny belongs here. Length of figured specimen 0.55 mm., which is slightly greater than Morrow's original measurement but agrees well with Cushman and Parker's plesiotype recorded above.

### **Bulimina reussi navarroensis** Cushman and Parker Plate 4, figure 10

*Bulimina reussi navarroensis* Cushman and Parker. — CUSHMAN AND RENZ, 1946, Cushman Lab. Foram. Res., Spec. Publ. 18, p. 37, pl. 6, fig. 11.

A few specimens of this species were found in sample no. 8, Nekhl. This variety is known from the Upper Cretaceous of the Gulf Coast region, as well as from the Lizard Springs marl of Trinidad.

Hypotype (U.S.N.M. P4101) from sample 8.

### **Bulimina stokesi** Cushman and Renz Plate 4, figure 14

*Bulimina stokesi* CUSHMAN AND RENZ, 1946, Cushman Lab. Foram. Res., Spec. Publ. 18, p. 37, pl. 6, fig. 14.

Specimens that closely resemble this Lizard Springs species were found in all the Danian and Paleocene samples (no. 837-852) of Giddi. This species resembles the Midway form *Bulimina arkadelphiana midwayensis* Cushman and Parker, but differs in having shorter and fewer costae and spines.

Hypotype (U.S.N.M. P4103) from sample 837.

### Genus **LACOSTEINA** Marie, 1945

#### **Lacosteina** cf. **L. gouskovi** Marie Plate 3, figure 39

*Lacosteina gouskovi* MARIE, 1945, Bull. Soc. Géol. France, ser. 5, vol. 13, p. 296, text-figs. 1-6.

A few specimens that seem to belong to this species were found in the Maestrichtian sample no. 6, Nekhl. The early planispiral stage occupies about one-quarter of the test, but the later part is without distinct sutures and is much longer in proportion to the test. This species was originally described from the Upper Cretaceous of Morocco.

Figured specimen (U.S.N.M. P4104) from sample 6.

### Genus **VIRGULINA** d'Orbigny, 1826

#### **Virgulina navarroana** Cushman Plate 4, figure 16

*Virgulina navarroana* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 126, pl. 53, figs. 5-7.

A large number of specimens of this species occur in the Maestrichtian sample no. 21, Nekhl. This is a distinctive species, known from the upper Navarro of the Gulf Coast region, which is of limited vertical occurrence in the Egyptian material.

Hypotype (U.S.N.M. P4105) from sample 21.

### **Virgulina** sp. Plate 4, figure 17

Test elongate, four times as long as broad, very slightly compressed, periphery rounded, twisted; chambers distinct, very slightly inflated, higher than broad; sutures distinct, depressed, slightly oblique; wall smooth; aperture elongate, narrow, running from the inner margin of the last-formed chamber to the apex.

A few specimens of this species are recorded from sample no. 6, Nekhl.

Figured specimen (U.S.N.M. P4106) from sample 6.

### Genus **BOLIVINA** d'Orbigny, 1839

#### **Bolivina decurrens parallela** Said and Kenawy, new variety Plate 4, figure 18

Variety differing from the typical form in having a more elongate test and in having the sutures of the early portion not strongly oblique. Length 0.55 mm.; breadth 0.25 mm.

This variety is a characteristic Maestrichtian form occurring in both the Giddi and the Nekhl material.

## SAID AND KENAWY

Holotype (U.S.N.M. P4107) from sample no. 6, Maestrichtian, Nekhl.

### **Bolivina incrassata** Reuss Plate 4, figure 19

*Bolivina incrassata* Reuss. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 127, pl. 53, figs. 8-11. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 20, pl. 10, figs. 4-5. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 117, pl. 17, fig. 25.

A large number of specimens of this robust and distinctive species occur in all the Maestrichtian samples of both sections. It has a definite vertical distribution in the upper Maestrichtian.

Hypotype (U.S.N.M. P4108) from sample 834.

### Genus **LOXOSTOMUM** Ehrenberg, 1854 **Loxostomum clavatum** (Cushman) Plate 4, figure 20

*Loxostoma clavatum* (Cushman). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 130, pl. 54, figs. 4-9.

Typical specimens of this species occur in samples no. 6 and 11, Nekhl, and no. 837, Giddi. These specimens show the crenulations at the base of the chambers less markedly than in the typical form.

Hypotype (U.S.N.M. P4109) from sample 837.

### **Loxostomum limonense** (Cushman) Plate 4, figure 21

*Loxostomum limonense* (Cushman). — CUSHMAN AND RENZ, 1946, Cushman Lab. Foram. Res., Spec. Publ. 18, p. 39, pl. 6, fig. 23.

A large number of specimens of this species occur in samples no. 6, 7 and 8, Nekhl, and no. 833, 834, 835, 837, 839, and 842, Giddi. This species, originally described from the Velasco shale of Mexico and recorded also from the Lizard Springs of Trinidad and the Upper Cretaceous of North America, has the same range in Egypt.

Hypotypes (U.S.N.M. P4110) from sample 7.

### **Loxostomum minutissimum** Cushman Plate 4, figure 22

*Loxostoma minutissimum* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 131, pl. 54, fig. 16.

Specimens that seem to belong to this species were found in the Maestrichtian samples no. 833 and 834, Giddi, and the Danian sample no. 7, Nekhl. These specimens are smaller than the American form, and have the later chambers strongly inflated and large.

Hypotype (U.S.N.M. P4111) from sample 7.

### **Loxostomum tegulatum** (Reuss) Plate 4, figure 23

*Loxostomum tegulatum* (Reuss)? — CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 9, p. 168, pl. 20, figs. 17-18. *Loxostomum tegulatum* (Reuss). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 38, pl. 10, figs. 25-26.

Specimens that resemble LeRoy's record of this species were found in the Maestrichtian sample no. 6, Nekhl.

Hypotype (U.S.N.M. P4112) from sample 6.

### Genus **BIFARINA** Parker and Jones, 1872

#### **Bifarina antiqua** Said and Kenawy, new species Plate 4, figure 28

Test elongate, slender, somewhat rounded in transverse section; earlier portion slightly compressed, biserial, in the adult with several distinctly uniserial chambers; chambers distinct, those of the earlier portion somewhat broader than high, increasing gradually in height as added, in the adult with height and breadth about equal; sutures distinct, depressed, slightly oblique both in uniserial and biserial portions; aperture in the adult becoming terminal, rounded, small, somewhat raised on an inflation of the last chamber. Length 0.4 mm.; breadth 0.08 mm.

This species is distinct. It differs from *Bifarina tenuilissa* Tappan in having a less slender test, a large biserial portion, and an elevated aperture. It occurs in samples no. 6 and 7, Nekhl, and no. 833, and 834, Giddi.

Holotype (U.S.N.M. P4113) from sample no. 834, Maestrichtian, Giddi.

### Genus **RECTUVIGERINA** Mathews, 1945

#### **Rectuvigerina advena** Said and Kenawy, new species Plate 4, figure 24

Test elongate, slender, three and one-half times as long as broad, tapering, greatest width developed by the last-formed chamber, apertural end rounded in cross section, initial end indistinct but triangular in cross section, early portion triserial, later becoming uniserial; chambers of the adult uniserial portion distinct, somewhat inflated, and of uniform size and shape; sutures distinct, slightly depressed, particularly in the uniserial portion; wall calcareous, with thin and indistinct longitudinal striae on the apparently smooth test; aperture rounded, terminal, projecting on a small neck, with a poorly developed lip; internal tube thin, aligned with the aperture, obvious only in clarifying media, particularly in the last uniserial chambers. Length 0.25 mm.; breadth 0.07 mm.

Study of a large number of specimens of this small species has shown that all are triserial in their earlier part and that this species, as far as we can tell, does not show the dimorphic character shown by *Siphogenerina*, as demonstrated by Bandy (1952), and therefore should belong to *Rectuvigerina*.

## FORAMINIFERA FROM SINAI

This species occurs in the lower Paleocene sample no. 8, Nekhl. The holotype (U.S.N.M. P4114) comes from this horizon.

### Genus SIPHOCENERINA Schlumberger, 1882

#### *Siphogenerina* sp.

Plate 4, figure 25

Test elongate, very slightly tapering, four times as long as broad; apertural end broadly rounded; initial end somewhat compressed and biserial in the microspheric form; later chambers uniserial, somewhat inflated and of rather uniform size and shape; sutures distinct, depressed; wall smooth, translucent; aperture terminal, rounded; internal tube thin, aligned with the aperture, appearing clearly in clarifying liquid as a thin straight tube extending from the aperture to the initial end. Length 1 mm.; breadth 0.25 mm.

Only the microspheric form of this species has been found in the Maestrichtian sample no. 6, Nekhl. This is clearly a *Siphogenerina*, from the characters of the early part of the microspheric form and the alignment of the tube (Bandy, 1952).

Figured specimen (U.S.N.M. P4115) from sample 6.

### Genus FISSURINA Reuss, 1850

#### *Fissurina orbigniana* Seguenza

Plate 7, figure 20

*Entosolenia orbigniana* (Seguenza). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 126, pl. 52, figs. 16-19.

Typical specimens of this species were found in samples no. 6 and 7, Nekhl, and no. 833 and 834, Giddi. These specimens fit the measurements and descriptions of the American material. The range of this species in Egypt is similar to its distribution in the Gulf Coast and Trinidad.

Hypotype (U.S.N.M. P4116) from sample 6.

### Genus OOLINA d'Orbigny, 1839

#### *Oolina reussi* Said and Kenawy, new species

Plate 7, figure 15

Test oval in outline, rounded in cross section, smooth, consisting of one chamber; aperture terminal, projecting, with an entosolenian tube composed of a thin unfolded plate. Length 1 mm.; breadth 0.3 mm.

This species resembles *Lagena apiculata* Reuss but differs in having the entosolenian tube, which is apparent only when the specimen is immersed in a clarifying oil, and in having a more rounded initial end.

Several specimens of this species were found in samples no. 835 and 837, Giddi, and no. 6, Nekhl.

Holotype (U.S.N.M. P4117) from sample no. 6, Maestrichtian, Nekhl.

### *Oolina* sp.

Plate 7, figure 14

A few small, rounded, spherical specimens with apertures that are not projecting and with tubes were found in sample no. 837, Giddi. The figured specimen (U.S.N.M. P4118, from sample 837) has a length of 0.25 mm. and a breadth of 0.2 mm.

### Family ELLIPSOIDINIDAE

#### Genus PLEUROSTOMELLA Reuss, 1860

#### *Pleurostomella subnodososa* Reuss

Plate 4, figure 26

*Pleurostomella subnodososa* Reuss. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 132, pl. 55, figs. 1-9. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 120, pl. 18, fig. 6a-b.

Specimens that seem to belong to this species were found in samples no. 834, Giddi, and no. 7 and 8, Nekhl.

Hypotype (U.S.N.M. P4119) from sample 834.

### Genus NODOSARELLA Rzehak, 1895

#### *Nodosarella gracillima* Cushman

Plate 4, figure 27

*Nodosarella gracillima* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 134, pl. 55, figs. 19-21. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 120, pl. 18, fig. 11a-b.

A few typical specimens of this species were found in the Maestrichtian and Danian samples no. 6 and 7, Nekhl, and no. 833, 837 and 838, Giddi. There is some biseriality shown in some specimens in the early part of the test, and this species may therefore belong to *Ellipsoidella*.

Hypotype (U.S.N.M. P4120) from sample 7.

### *Nodosarella minuta* Said and Kenawy, new species

Plate 4, figure 30

Test minute, very elongate, slender, tapering, greatest breadth toward apertural end, circular in transverse section; early chambers showing traces of biseriality, later ones uniserial, rectilinear; chambers distinct, very slightly inflated, increasing in size and length toward the apertural end, eight to ten in number; sutures depressed; wall smooth, perforate; aperture semielliptical, slightly to one side of the end of the last-formed chamber. Length 0.4 mm.; breadth 0.07 mm.

This is a distinctive species characterized by its minute size, slender test, and rectilinear alignment of chambers. It occurs in samples no. 7 and 8, Nekhl.

Holotype (U.S.N.M. P4121) from sample no. 8, Paleocene, Nekhl.

**Nodosarella misrensis** Said and Kenawy, new species  
Plate 4, figure 29

Test elongate, tapering, increasing in diameter from the subacute initial end, slightly arcuate; chambers distinct, somewhat longer than broad, becoming inflated in the adult portion; wall smooth but ornamented with spines occupying the middle of each chamber; aperture terminal, broadly crescentic, with a short, indistinct neck. Length 1.5 mm.; breadth 0.15 mm.

This species has all the characters of genus *Stilostomella* except for the *Nodosarella*-like aperture. A few specimens of this species are known from the Maestrichtian sample no. 6, Nekhl.

Holotype (U.S.N.M. P4122) from sample no. 6, Maestrichtian, Nekhl.

**Nodosarella subnodososa** (Guppy)  
Plate 4, figure 31

*Nodosarella subnodososa* (Guppy). — CUSHMAN AND STAINFORTH, 1945, Cushman Lab. Foram. Res., Spec. Publ. 14, p. 53, pl. 9, fig. 3.

Specimens that closely resemble those recorded from the Oligocene of Trinidad were found in the Egyptian material in the Paleocene sample no. 8, Nekhl. The specimens do not show the early biserial stage of the type record, and therefore may belong to another species.

Hypotype (U.S.N.M. P4123) from sample 8.

Genus STILOSTOMELLA Guppy, 1894

**Stilostomella alexanderi alexanderi** (Cushman)  
Plate 4, figure 33

*Ellipsonodosaria alexanderi* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 135, pl. 56, figs. 12-15.

*Ellipsonodosaria alexanderi* Cushman var. *alexanderi* Cushman. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 121, pl. 18, figs. 13-14.

A few specimens that seem to belong to this species are recorded from the Danian and Paleocene samples no. 837, 838, and 842, Giddi, and no. 8, Nekhl. Our specimens are stouter, with fewer spines, and the chambers are not inflated.

Hypotypes (U.S.N.M. P4124) from sample 838.

**Stilostomella alexanderi impensa** (Cushman)  
Plate 4, figure 32

*Ellipsonodosaria alexanderi* Cushman var. *impensa* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 136, pl. 56, figs. 16-18. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 121, pl. 18, figs. 15-16.

This species is recorded from the Maestrichtian sample no. 6, Nekhl. It seems to occur in the same stratigraphic horizon as in North America.

Hypotype (U.S.N.M. P4125) from sample 6.

**Stilostomella horridens** (Cushman)  
Plate 4, figure 38

*Ellipsonodosaria horridens* CUSHMAN, 1936, Contr. Cushman Lab. Foram. Res., vol. 12, p. 53, pl. 9, figs. 19-21. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 136, pl. 56, figs. 21-23.

A few specimens of this species were found in sample no. 6, Nekhl. The characteristic spinose ornamentation of the test distinguishes this species, which occurs in the Egyptian material at the same horizon from which it is recorded in North America.

Hypotype (U.S.N.M. P4126) from sample 6.

**Stilostomella paleocenica** (Cushman and Todd)  
Plate 4, figure 39

*Ellipsonodosaria paleocenica* CUSHMAN AND TODD, 1946, Contr. Cushman Lab. Foram. Res., vol. 22, p. 61, pl. 10, fig. 26.

Numerous typical specimens of this species occur in the Danian samples of both Nekhl and Giddi. This species seems to be restricted to this horizon in Egypt, and does not appear in later samples, as is the case in North America.

Hypotypes (U.S.N.M. P4127) from sample 7.

**Stilostomella stephensi** (Cushman)  
Plate 4, figure 37

*Ellipsonodosaria stephensi* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 134, pl. 56, figs. 2-7. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 121, pl. 18, figs. 22-23.

A few specimens of this upper Taylor and Navarro species occur in the Maestrichtian sample no. 833, Giddi.

Hypotype (U.S.N.M. P4128) from sample 833.

Genus ELLIPSOGLANDULINA Silvestri, 1900

**Ellipsoglandulina exponens** (H. B. Brady)  
Plate 4, figure 35

*Ellipsoglandulina exponens* (Brady). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 137, pl. 56, figs. 34-36.

This species, known from the Cretaceous and Paleocene of the Tampico Embayment of Mexico, is restricted in the material studied to the Danian sample no. 7, Nekhl.

Hypotype (U.S.N.M. P4129) from sample 7.

**Ellipsoglandulina ellisi** Said and Kenawy,  
new species  
Plate 4, figure 34

Test small, somewhat elongate, slightly tapering; chambers distinct, increasing gradually in diameter and length as added, slightly overlapping; sutures depressed; wall smooth, finely perforate; aperture an elongate, narrow curved slit at the end of the last-formed chamber.

## FORAMINIFERA FROM SINAI

This species is similar to and probably identical with *Ellipsonodosaria subnodososa* (Guppy) of Cushman (1946, U. S. Geol. Survey, Prof. Paper 206, p. 137, pl. 56, figs. 30-31) from the Lizard Springs formation of Trinidad.

Holotype (U.S.N.M. P4130) from sample No. 833, Giddi. Several specimens are also recorded from sample no. 847, Giddi.

### ***Ellipsoglandulina velascoensis* Cushman** Plate 4, figure 36

*Ellipsoglandulina velascoensis* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 137, pl. 56, fig. 37.

This species, originally described from the Mexican Velasco shale, is recorded in small numbers from sample no. 6, Nekhl.

Holotype (U.S.N.M. P4131) from sample 6.

### Genus **ELLIPSOIDELLA** Heron-Allen and Earland, 1910

#### ***Ellipsoidella pleurostomelloides* Heron-Allen and Earland** Plate 4, figure 40

*Ellipsoidella pleurostomelloides* HERON-ALLEN AND EARLAND, 1910, Jour. Roy. Micr. Soc., p. 415, pl. 10, figs. 1-11; pl. 11, figs. 1-2.

Test cylindrical, elongate; early chambers somewhat compressed and arranged in an irregularly biserial manner, later chambers spherical, nodosarian; aperture terminal, a crescentic slit, surmounted by a raised and overhanging process. Several specimens of this species were found in samples no. 7 and 8, Nekhl, and no. 833, 834, and 839, Giddi.

Holotype (U.S.N.M. P4132) from sample 834.

#### Superfamily ROTALIIDEA

##### Family ROTALIIDAE

###### Subfamily VALVULINERIINAE

###### Genus **VALVULINERIA** Cushman, 1926

###### ***Valvulineria aegyptiaca* LeRoy** Plate 4, figure 45

*Valvulineria aegyptiaca* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 53, pl. 9, figs. 21-23.

Several specimens of this species were found in samples no. 7 and 9, Nekhl, and no. 852, Giddi.

Holotype (U.S.N.M. P4133) from sample 7.

###### ***Valvulineria esnehensis* Nakkady** Plate 4, figure 41

*Valvulineria esnehensis* NAKKADY, 1950, Jour. Pal., vol. 24, p. 689, pl. 90, figs. 11-13. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 53, pl. 7, figs. 29-30.

This is an ubiquitous species which is recorded in con-

siderable numbers from samples no. 833, 837, 838, 839, 842, 847, and 852, Giddi, and no. 8 and 11, Nekhl. It is a well-defined species.

Hypotype (U.S.N.M. P4134) from sample 8.

###### ***Valvulineria scrobiculata* (Schwager)** Plate 4, figure 42

*Anomalina scrobiculata* SCHWAGER, 1883, Palaeontographica, vol. 30, pt. 1, p. 129, pl. 29, fig. 18.

*Valvulineria scrobiculata* (Schwager). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 53, pl. 9, figs. 18-20.

A few specimens of this species were found in the upper Paleocene sample no. 11. These specimens resemble those recorded by LEROY from his unit II, except for the fact that they possess an apparently less open umbilicus.

Hypotypes (U.S.N.M. P4135) from sample 11.

###### Genus **GLOBOROTALIA** Cushman, 1927

###### ***Globorotalia membranacea* (Ehrenberg)** Plate 4, figure 46

*Globorotalia membranacea* (Ehrenberg). — CUSHMAN AND BERMEDEZ, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, p. 34, pl. 6, figs. 16-18.

Typical specimens of this species are recorded from the lower Paleocene sample no. 8, Nekhl. The range of this species in Egypt is similar to its range in Cuba.

Holotype (U.S.N.M. P4136) from sample 8.

###### Genus **GLOBOROTALITES** Brotzen, 1942

###### ***Globorotalites conicus* (Carsey)** Plate 4, figure 43

*Globorotalia micheliniana* (d'Orbigny). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 152, pl. 63, figs. 2-3.

Typical specimens of this upper Taylor species are recorded from all the Maestrichtian samples of both sections. This species is an index fossil for this age in Egypt.

Holotype (U.S.N.M. P4137) from sample 6.

###### Genus **GAVELINELLA** Brotzen, 1942

###### ***Gavelinella brotzeni* Said and Kenawy, new species** Plate 4, figure 47

Test much compressed, trochoid, biconvex, the dorsal side evolute, periphery rounded, umbilicus open; chambers numerous, nine or ten in the last-formed whorl, distinct; sutures distinct on the dorsal side, nearly flush with the surface, slightly curved on the ventral side, slightly depressed, nearly radial; wall smooth; aperture on the ventral side, extending from the periphery to the umbilicus, but extending dorsally between the last two whorls. Diameter 0.6 mm.; height 0.2 mm.

This species is similar to and perhaps identical with *Gyroidina depressa* (Alth) as described by Cushman (1946 (part), p. 139, pl. 58, figs. 3-4, *non* figs. 1-2) and by Plummer (1931, p. 190, pl. 13, fig. 3). Brotzen (1942, p. 54) stated that Cushman's *Gyroidina depressa* is in reality *Gavelinella cretacea* (Carsey), but the latter species was put in synonymy with *Gyroidina depressa* (Alth) in Frizzell's recent Handbook (1954, p. 123).

This species occurs in the Maestrichtian samples no. 6, Nekhl, and no. 834 and 835, Giddi.

Holotype (U.S.N.M. P4138) from sample no. 6, Maestrichtian, Nekhl.

**Gavelinella brotzeni paleocenica** Said and Kenawy,  
new variety  
Plate 4, figure 44

Variety differing from the typical form in having a more compressed test, a less open umbilicus, and limbate sutures on the dorsal side. Diameter 0.5 mm.; height 0.15 mm.

This variety is recorded from the upper Paleocene sample no. 11, Nekhl. The holotype (U.S.N.M. P4139) comes from this sample.

**Gavelinella cf. G. pertusa** (Marsson)  
Plate 5, figure 1

*Gavelinella pertusa* (Marsson). — BROTZEN, 1942, Sver. Geol. Unders., ser. C, no. 451, p. 41, pl. 1, figs. 1-2.

Specimens that resemble this European Upper Cretaceous species occur in the Maestrichtian sample no. 833, Giddi. Our specimens have a narrower umbilicus and higher chambers.

Figured specimen (U.S.N.M. P4140) from sample 833.

Genus EPONIDES Montfort, 1808

**Eponides lunatus** Brotzen  
Plate 5, figure 3

*Eponides lunata* BROTZEN, 1948, Sver. Geol. Unders. ser. C, no. 493, p. 77, pl. 10, figs. 17-18.

*Eponides lunatus* Brotzen. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 30, pl. 9, figs. 24-26.

This Swedish Paleocene species is recorded from the Paleocene samples no. 11, Nekhl, and no. 842, Giddi.

Hypotype (U.S.N.M. P4141) from sample 842.

**Eponides mariei** Said and Kenawy, new species  
Plate 5, figure 2

Test circular in outline, biconvex in side view, dorsal and ventral sides equally high, periphery rounded; chambers in several whorls, five or six in the adult whorl, distinct in the last whorl but somewhat indistinct in the earlier

whorls, slightly inflated on the ventral side; sutures depressed, nearly radiate; wall smooth, distinctly perforate; aperture ventral, between the umbilicus and the periphery. Diameter 0.25 mm.; height 0.15 mm.

This species is characterized by its biconvex test and indistinct earlier spiral sutures and chambers. It occurs abundantly in the Maestrichtian and Danian samples of Giddi.

Holotype (U.S.N.M. P4142) from sample no. 834, Maestrichtian, Giddi.

**Eponides simplex** (White)  
Plate 5, figure 4

*Eponides simplex* (White). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 142, pl. 57, fig. 15.

This species, known from the Lizard Springs formation of Trinidad and the Mexican Velasco shale, is recorded in the Egyptian material from the Danian and Paleocene samples no. 7 and 8, Nekhl, and no. 837, 840, 842, 843, 848 and 859, Giddi.

Hypotypes (U.S.N.M. P4143) from sample 7.

**Eponides sigali** Said and Kenawy, new species  
Plate 5, figure 6

Test nearly circular in outline, in side view biconvex, dorsal side slightly lower than ventral side; periphery strongly rounded; chambers about seven in the adult whorl, indistinct in the earlier part of the dorsal side and faint in the adult whorl, slightly inflated ventrally; sutures depressed, indistinct; wall smooth, perforate; aperture ventral, elongate, between the umbilicus and the periphery. Diameter 0.7 mm.; height 0.4 mm.

This species is characterized by its biconvex side view, large test, and indistinct chambers.

Holotype (U.S.N.M. P4144) from sample no. 6, Maestrichtian, Nekhl.

Genus GYROIDINA d'Orbigny, 1826

**Gyroidina girardana** (Reuss)  
Plate 5, figure 7

*Gyroidina girardana* (Reuss). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 140, pl. 58, fig. 9. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 35, pl. 5, figs. 10-12. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 123, pl. 18, fig. 37a-c.

A large number of typical specimens of this species were found in the Maestrichtian samples no. 6, Nekhl, and no. 833, 834 and 835, Giddi. LeRoy records this species at a slightly higher level, from the basal Eocene (unit IV) of Maqfi, Egypt, and indicates that it is a stratigraphic marker for that age, but the occurrence of this species, which is known also from the American Upper Cretaceous, in our material either indicates that it has a

## FORAMINIFERA FROM SINAI

longer range than LeRoy believed, or may indicate a different age for LeRoy's "basal Eocene."

Hypotypes (U.S.N.M. P4145) from sample 835.

### **Gyroidina depressa** (Alth.)

Plate 5, figure 11

*Gyroidina depressa* (Alth.) — CUSHMAN, 1946 (part), U. S. Geol. Survey, Prof. Paper 206, p. 139, pl. 58, figs. 1-2 (non figs. 3-4). — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 123, pl. 18, fig. 36a-c.

Typical specimens of this species as recorded by Frizzell and by Cushman were found in the Paleocene sample no. 11, Nekhl, and in the Lower Eocene sample no. 859, Giddi.

Hypotypes (U.S.N.M. P4146) from sample 11.

### **Gyroidina globosa** (Hagenow)

Plate 5, figure 5

*Gyroidina globosa* (Hagenow) — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 140, pl. 58, figs. 6-8. — FRIZZELL, 1954, Univ. Texas Rept. Invest. no. 22, p. 124, pl. 18, fig. 40a-c.

Typical specimens of this characteristic species were found in the Paleocene samples no. 7 and 11, Nekhl, and no. 852 and 859, Giddi. This species is recorded from the Upper Cretaceous of the Gulf Coast area and the Lizard Springs formation of Trinidad. In Egypt it seems to have a wider range, from the Danian to the Lower Eocene.

Hypotypes (U.S.N.M. P4147) from sample 11.

### **Gyroidina planulata** Cushman and Renz

Plate 5, figure 8

*Gyroidina planulata* Cushman and Renz. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 35, pl. 11, figs. 1-3.

Specimens identical with those recorded by LeRoy from the Maqfi section were noted in the Danian sample no. 7, Nekhl. LeRoy's record extends from the "basal Eocene" to the Lower Eocene. These specimens differ from Cushman and Renz's original in having a flatter dorsal side, and may deserve a new name.

Hypotype (U.S.N.M. P4148) from sample 7.

### **Gyroidina reussi** Said and Kenawy, new species

Plate 5, figure 10

*Gyroidina nitida* (Reuss). — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 140, pl. 58, fig. 5.

Test free, small, trochoid, periphery broadly rounded; all chambers of the one and one-half to two whorls visible on the slightly flattened dorsal side, only the six chambers of the final whorl visible on the more convex ventral side; sutures distinct, radial, slightly curved; wall calcareous, perforate, surface smooth; aperture a low slit at the base of the last chamber.

Specimens that resemble those described by Cushman from the Gulf Coast area are recorded from samples no. 838 and 840, Giddi. These specimens have the development of the last chamber, the size, and the chamber arrangement on the dorsal side similar to that of "*Gyroidina nitida* (Reuss)", but a new name is proposed for them because Reuss's original *Rotalia nitida* has been removed to *Gyroidinoides*.

Holotype (U.S.N.M. P4149) from sample 838, Danian, Giddi.

### **Gyroidina subangulata** (Plummer)

Plate 5, figure 9

*Rotalina soldanii* (d'Orbigny) var. *subangulata* PLUMMER, 1927, Univ. Texas Bull. 2844, p. 154, pl. 12, fig. 1a-c.

*Gyroidina subangulata* (Plummer). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 35, pl. 3, figs. 23-25.

This species, originally described from the Midway of Texas, occurs in large numbers in the Paleocene samples no. 11, Nekhl, and no. 839, 842 and 848, Giddi.

Hypotypes (U.S.N.M. P4149) from sample 842.

### Genus **GYROIDINOIDES** Brotzen, 1942

#### **Gyroidinoides frizzelli** Said and Kenawy,

new species

Plate 5, figure 13

Test much compressed, biconvex, the dorsal side nearly flat, periphery rounded, umbilicus open; chambers numerous, eleven or twelve in the last-formed whorl, distinct; sutures distinct, strongly curved on the dorsal side, less curved on the ventral side, depressed; wall smooth; aperture on the ventral side, extending to the umbilicus. Diameter 0.3 mm.; height 0.08 mm.

This is a distinctive species, characterized by its compressed test, distinct sutures, and open umbilicus. This species occurs in sample no. 11, Nekhl. The holotype (U.S.N.M. P4152) comes from this sample (Esna shale, Paleocene).

### **Gyroidinoides nitidus** (Reuss)

Plate 5, figure 12

*Rotolina nitida* Reuss. — REUSS, 1845, Verstein. Böhm, Kreideform., pt. 1, p. 35, pl. 8, fig. 52; pl. 12, figs. 8, 20.

Specimens that resemble this European Cretaceous species were found in the Maestrichtian sample no. 6, Nekhl. This species is the type species of the genus, and Brotzen's description is sufficient.

Hypotype (U.S.N.M. P4153) from sample 6.

### Genus **STENSIÖINA** Brotzen, 1936

#### **Stensiöina americana** Cushman and Dorsey

Plate 6, figure 1

*Stensiöina americana* Cushman and Dorsey. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 141, pl. 65, fig. 14.

## SAID AND KENAWY

Typical specimens of this upper Taylor and Navarro species are recorded in our material from all the Maestrichtian samples of both sections.

Hypotypes (U.S.N.M. P4154) from sample 6.

### **Stensiöina excolata** (Cushman)

Plate 6, figure 2

*Stensiöina excolata* Cushman. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 141, pl. 66, fig. 17a-c.

A few specimens that seem to belong to this species are known from all the Maestrichtian samples of both sections. This species seems to be an excellent index fossil for this age. It occurs in the comparable Mendez shale of Mexico.

Hypotype (U.S.N.M. P4155) from sample 6.

### Subfamily GLOBOTRUNCANINAE

#### Genus GLOBOTRUNCANA Cushman, 1927

##### **Globotruncana aegyptiaca** Nakkady

Plate 5, figure 19

*Globotruncana aegyptiaca* NAKKADY, 1950, Jour. Pal., vol. 24, p. 690, pl. 90, figs. 20-22.

A few specimens of this species are recorded from all the Maestrichtian samples of both sections. The distribution of this species in the sections studied by Nakkady agrees well with that of our material.

Hypotype (U.S.N.M. P4156) from sample 6.

##### **Globotruncana caliciformis** Vogler

Plate 5, figure 18

*Rosalina linnei* d'Orbigny, "mutation caliciforme," DE LAPARENT, 1918, Mém. Serv. Carte Géol. France, p. 8, text-fig. 2j; pl. 1, fig. 2.

*Globotruncana caliciformis* (de Lapparent) [Vogler]. — BOLLI, 1951, Jour. Pal., vol. 25, p. 194, pl. 34, figs. 4-6.

Typical specimens of this species were found in samples no. 6, Nekhl, and no. 833 and 834, Giddi. These specimens have the typical radial arrangement of the sutures on the ventral side. This species is closely related to *Globotruncana stuarti*, but has less oblique sutures, less convexity on the ventral side, fewer chambers, and a keel-like border rather than a beaded periphery.

Hypotype (U.S.N.M. P4157) from sample 6.

##### **Globotruncana conica** White

Plate 5, figure 16

*Globotruncana conica* White. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 151, pl. 61, fig. 20a-c. — BOLLI, 1951, Jour. Pal., vol. 25, p. 196, pl. 34, figs. 13-15.

Numerous typical specimens of this species occur in all the Maestrichtian samples of our material. Bolli considers this species closely related to *Globotruncana stuarti*, and our

material adds evidence for this conclusion, as the two species are usually associated.

Hypotype (U.S.N.M. P4158) from sample 6.

##### **Globotruncana esnehensis** Nakkady

Plate 5, figure 21

*Globotruncana arca* (Cushman) var. *esnehensis* NAKKADY, 1950 Jour. Pal., vol. 24, p. 690, pl. 90, figs. 23-26.

This species, originally described as a variety of *Globotruncana arca* (Cushman), is here raised to specific rank, as a result of Bolli's conclusive studies of Cushman's species. *Globotruncana esnehensis* is obviously not related to *Globotruncana arca* as it is now understood. The dorsal side shows more than one whorl, the chambers increase gradually in size as added, and the test is characterized by a rather concave ventral side, a keel, and somewhat radial, indistinctly beaded sutures. A few specimens of this species occur in all our Maestrichtian samples.

Hypotype (U.S.N.M. P4159) from sample 6.

##### **Globotruncana gansseri** Bolli

Plate 5, figure 17

*Globotruncana gansseri* BOLLI, 1951, Jour. Pal., vol. 25, p. 196, pl. 35, figs. 1-3.

Typical specimens of this species occur abundantly in samples no. 833 and 834, Giddi, and less abundantly in samples no. 835, Giddi, and no. 6, Nekhl. There is some variation in this species with regard to the degree of convexity on the ventral side. The more or less flattened dorsal side and the strongly convex ventral side with a wide umbilicus characterize this distinctive species.

Hypotype (U.S.N.M. P4160) from sample 6.

##### **Globotruncana lapparenti lapparenti** Brotzen

Plate 5, figure 14

*Rosalina linnei* d'Orbigny, type 1, DE LAPARENT, 1918, Mém. Serv. Carte Géol. France, p. 4, text-fig. 1a, c.

A single specimen of this subspecies (hypotype, U.S.N.M. P4161), was found in sample no. 6, Nekhl.

##### **Globotruncana lapparenti tricarinata** (Quereau)

Plate 5, figure 20

*Rosalina linnei* d'Orbigny, type 2, DE LAPARENT, 1918, Mém. Serv. Carte Géol. France, p. 4, text-fig. 1b, d, e, f.

*Globotruncana canaliculata* (REUSS). — CUSHMAN, 1946 (part), U. S. Geol. Survey, Prof. Paper 206, p. 149, pl. 61, fig. 18a-c (not fig. 17).

A few specimens of this species were found in sample no. 21, lower Maestrichtian, Nekhl. Our record shows that this species has a longer range in Egypt than in Central America.

Hypotype (U.S.N.M. P4162) from sample 21.

## FORAMINIFERA FROM SINAI

### **Globotruncana mayaroensis** Bolli Plate 5, figure 23

*Globotruncana mayaroensis* BOLLI, 1951, Jour. Pal., vol. 25, p. 198, pl. 35, figs. 10-12.

A few specimens of this species are known from samples no. 835, Giddi, and no. 6, Nekhl. Our specimens correspond to the measurements and descriptions of the Trinidad specimens as recorded by Bolli.

Hypotype (U.S.N.M. P4164) from sample 6.

### **Globotruncana intermedia** Bolli Plate 5, figure 15

*Globotruncana intermedia* BOLLI, 1951, Jour. Pal., vol. 25, p. 197, pl. 35, figs. 7-9.

A few typical specimens of this species were found in all the Maestrichtian samples of both sections.

Hypotype (U.S.N.M. P4163) from sample 833.

### **Globotruncana stuarti** (de Lapparent) Plate 5, figure 22

*Rosalina stuarti* DE LAPPARENT, 1918, Mém. Serv. Carte Géol. France, pp. 11-14; p. 12, text-fig. 4; p. 13, text-fig. 5a-c.

*Globotruncana arca* (Cushman).—CUSHMAN, 1946 (part), U. S. Geol. Survey, Prof. Paper 206, p. 150, pl. 62, fig. 5a-c (not fig. 4).

*Globotruncana stuarti* (de Lapparent).—BOLLI, 1951, Jour. Pal., vol. 25, p. 196, pl. 34, figs. 10-12.

This is an abundant species in the Egyptian material and seems to indicate that the lower shale samples from Giddi and the Chalk samples studied from Nekhl are of Maestrichtian age. Our specimens are typical and they agree well with Bolli's descriptions of Trinidad specimens. This species is distinguished by its characteristic side view, oblique beaded sutures, and numerous chambers.

Hypotype (U.S.N.M. P4165) from sample 6.

### Genus TRUNCOROTALIA Cushman and Bermudez, 1949

#### **Truncorotalia colligera** (Schwager) Plate 6, figure 5

*Globorotalia (Truncorotalia) wilcoxensis* Cushman and Ponton var. *acuta* Toulmin.—CUSHMAN AND BERMUDEZ, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, p. 39, pl. 7, figs. 19-21.

This species occurs abundantly in samples no. 11, Nekhl, and no. 859, Giddi. The distribution of this species in Egypt is similar to its distribution in Cuba, where it is a marker for the Paleocene.

Hypotype (U.S.N.M. P4166) from sample 11.

#### **Truncorotalia crassata aequa** (Cushman and Renz) Plate 6, figure 8

*Globorotalia (Truncorotalia) crassata* Cushman var. *aequa* Cushman and Renz.—CUSHMAN AND BERMUDEZ, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, p. 37, pl. 7, figs. 7-9.

A number of specimens referable to this species are index fossils for the Nekhl Paleocene (sample no. 11), but appear at a higher level in Giddi (sample no. 859). This discrepancy is interpreted as an indication of ecologic differences resulting from the peculiar basin of sedimentation (see remarks on *Truncorotalia velascoensis*).

Hypotype (U.S.N.M. P4167) from sample 11.

#### **Truncorotalia esnaensis** (LeRoy) Plate 6, figure 7

*Globigerina esnaensis* LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 31, pl. 6, figs. 8-10.

Specimens of this species that are identical with those figured by LeRoy are recorded from the Paleocene samples of both sections. This species should belong to the genus *Truncorotalia*, as the strongly flattened ventral side and apertural characters suggest.

Hypotype (U.S.N.M. P4169) from sample 11.

#### **Truncorotalia simulabilis** (Schwager) Plate 6, figure 6

*Discorbina simulabilis* SCHWAGER, 1883, Palaeontographica, vol. 30, pt. 1, p. 120, pl. 29(6), fig. 15a-d.

*Globorotalia simulabilis* (Schwager).—NAKKADY, 1951, Bull. Fac. Sci. Alexandria Univ., no. 1, p. 53, pl. 1, fig. 5.

This species occurs in our material only in the Lower Eocene samples no. 862 and 867, Giddi. The limited occurrence of this excellent index fossil is in harmony with Schwager's original record of this species in the lower Libyan. Nakkady's record may need revision; he reports this species as abundant in almost all his shale samples. If his record is valid, this species will lose its value as an index fossil for the Lower Eocene.

Hypotypes (U.S.N.M. P4170) from sample 867.

#### **Truncorotalia spinulosa** (Cushman) Plate 6, figure 3

*Globorotalia (Truncorotalia) spinulosa* Cushman.—CUSHMAN AND BERMUDEZ, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, p. 40, pl. 8, figs. 1-3.

Typical specimens of this species are known from the Lower Eocene sample no. 862, Giddi. It occurs at the same stratigraphic level as in Cuba and is a marker for the Egyptian Lower Eocene.

Hypotype (U.S.N.M. P4171) from sample 862.

## SAID AND KENAWY

### **Truncorotalia velascoensis (Cushman)** Plate 6, figure 4

*Globorotalia (Truncorotalia) velascoensis* (Cushman). — CUSHMAN AND BERMUDEZ, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, p. 41, pl. 8, figs. 4-6.

Numerous typical specimens of this species mark the lowest Paleocene samples in Nekhl, nos. 8 and 9. This species occurs at a much higher level in Giddi (sample no. 859) because it was planktonic and lived only in open, moderately deep waters, conditions which were not established in the Giddi area until after the great marine transgression of the Lower Eocene. This species, as well as the other *Truncorotalia* species, is of limited use in correlation in Egypt.

Hypotype (U.S.N.M. P4172) from sample 859.

### **Truncorotalia wilcoxensis (Cushman and Ponton)** Plate 6, figure 9

*Globorotalia (Truncorotalia) wilcoxensis* Cushman and Ponton. — CUSHMAN AND BERMUDEZ, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, p. 39, pl. 7, figs. 16-18.

This Cuban Paleocene species is known from the Paleocene sample no. 11, Nekhl.

Hypotype (U.S.N.M. P4173) from sample 11.

#### Subfamily EPISTOMININAE

##### **Genus Höglundina Brotzen, 1948**

###### **Höglundina esnaensis (LeRoy)** Plate 6, figure 14

*Epistomina esnaensis* LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 29, pl. 5, figs. 7-9.

A few specimens that may belong to this species were found in the Danian samples no. 7, Nekhl, and no. 840, Giddi. These specimens have fewer chambers and somewhat indistinct latero-marginal apertures.

Hypotype (U.S.N.M. P4174) from sample 7.

###### **Höglundina cf. H. scalaris (Franke)** Plate 6, figure 12

*Epistomina scalaris* FRANKE, 1927, Danmarks Geol. Unders., ser. 2, no. 46, p. 39, pl. 4, fig. 6.

This species, originally described from the Paleocene of Denmark, is recorded from the Egyptian Maestrichtian and Danian samples no. 6, Nekhl, and no. 835 and 837, Giddi. The specimens are less convex than those recorded by Franke. The latero-marginal aperture is only apparent when the periphery is etched and a view of the inferior septum and its reflecta (Brotzen, 1948, p. 93) is seen.

Figured specimen (U.S.N.M. P4175) from sample 837.

### **Genus OSANGULARIA Brotzen, 1940**

#### **Osangularia expansa (Toulmin)** Plate 6, figure 11

*Parrella expansa* Toulmin. — CUSHMAN, 1951, U. S. Geol. Survey, Prof. Paper 232, p. 53, pl. 16, figs. 11-12.

Specimens that can be referred to this species were found in Danian and Paleocene samples from Giddi (samples no. 838, 839 and 847). Our specimens have a more convex dorsal side.

Hypotype (U.S.N.M. P4176) from sample 839.

### **Genus PSEUDOPARRELLA Cushman and ten Dam, 1948**

#### **Pseudoparella obtusa (Burrows and Holland)** Plate 6, figure 10

*Pulvinulina exigua* Brady var. *obtusa* Burrows and Holland. — PLUMMER, 1927, Univ. Texas Bull. 2644, p. 151, pl. 11, fig. 2a-c.

*Pseudoparella obtusa* (Burrows and Holland). — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 45, pl. 10, figs. 21-23.

This Trinidad and Gulf Coast Midway species is recorded in considerable numbers from samples no. 7 and 8, Nekhl, and no. 833, 834, 843 and 848, Giddi.

Hypotype (U.S.N.M. P4177) from sample 8.

### **Genus ALABAMINA Toulmin, 1941**

#### **Alabamina wilcoxensis Toulmin** Plate 6, figure 18

*Alabamina wilcoxensis* Toulmin. — CUSHMAN, 1951, U. S. Geol. Survey, Prof. Paper 232, p. 57, pl. 16, figs. 6-7.

Specimens that closely resemble this species were found in the Paleocene samples of both sections studied. This species closely resembles Schwager's *Discorbina floscellus* (1883, Palaeontographica, vol. 30, pt. 1, pl. 27(4), fig. 11), which may be an *Alabamina*, but the apertural characters of Schwager's species are not apparent.

Hypotypes (U.S.N.M. P4178) from sample 852.

#### Subfamily SIPHONININAE

##### **Genus CHARLTONINA Bermudez, 1952**

###### **Charltonina toddae Said and Kenawy, new species** Plate 6, figure 15

Test biconvex; dorsal side convex, evolute; ventral side convex, involute; periphery acute, rounded in outline; chambers distinct, five in the last-formed whorl, earlier, dorsal chambers indistinct; sutures indistinct, radial, depressed; wall smooth, finely perforate; aperture at the ventral margin of the last-formed chamber and extending parallel to the periphery. Diameter 0.5 mm.; thickness 0.15 mm.

## FORAMINIFERA FROM SINAI

This is a characteristic species with peculiar apertural characters that resemble those of *Pseudoparrella*. It was found in samples no. 8, Nekhl, and no. 842 and 852, Giddi.

Holotype (U.S.N.M. P4179) from sample no. 852, Paleocene, Giddi.

### Subfamily ROTALIINAE

#### Genus STREBLUS Fischer, 1817

##### **Streblus convexus** (LeRoy)

Plate 6, figure 19

*Rotalia convexa* LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 48, pl. 9, figs. 13-15.

Typical specimens of this species were found in the Paleocene samples no. 11, Nekhl, and no. 852, Giddi. It was recorded by LeRoy from the "basal Eocene" of Maqfi, Farafra.

Hypotype (U.S.N.M. P4180) from sample 11.

#### Genus NEOROTALIA Bermudez, 1952

##### **Neorotalia** sp.

Plate 6, figure 13

Test trochoid, circular in outline, biconvex, dorsal side composed of two whorls; chambers numerous, distinct, much longer than high; sutures distinct, without papillae; ventral side with umbilical plug; wall opaque and dense; aperture elongate, between umbilicus and periphery. Diameter 0.4 mm.; height 0.15 mm.

A few specimens of this species were found in sample no. 7, Nekhl. An exact specific name cannot be given because the specimens are so few that it was not possible to section them to ascertain the inner structure.

Figured specimen (U.S.N.M. P4181) from sample 7.

### Family ANOMALINIDAE

#### Subfamily ANOMALININAE

#### Genus ANOMALINA d'Orbigny, 1826

##### **Anomalina grandis** LeRoy

Plate 6, figure 16

*Anomalina grandis* LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 18, pl. 9, figs. 6-8.

A number of specimens of this species were found in samples no. 6, 8, and 11, Nekhl, and no. 837, Giddi. The apertural characters of our specimens are different from those described and figured by LeRoy. The aperture extends ventrally, indicating a possible relationship of this species to the genus *Cibicidoides*.

Hypotype (U.S.N.M. P4182) from sample 8.

#### **Anomalina granosa** (Hantken)

Plate 6, figure 20

*Anomalina granosa* (Hantken). — LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 17, pl. 6, figs. 1-3.

A large number of specimens of this typical perforate species were found in numerous Danian, Paleocene and Lower Eocene samples from both Nekhl (no. 7, 8, 9, and 11) and Giddi (no. 837, 839, 840, 842, 843, 847, 848, 852, 859 and 862).

Hypotype (U.S.N.M. P4215) from sample 11.

#### **Anomalina misrensis** Said and Kenawy, new species

Plate 6, figure 22

Test medium-sized nearly symmetrical, biconvex; chambers numerous, distinct; ventral side more umbilicate; sutures strongly oblique, distinct and depressed dorsally, indistinct and slightly limbate ventrally; wall smooth, with extremely fine perforations; aperture an elongate slit at the base of the last chamber, interiomarginal. Diameter 0.5 mm.; thickness 0.2 mm.

The umbilicate ventral side with limbate and strongly curved sutures characterizes this species.

A number of specimens of this species were found in samples no. 9 and 11, Nekhl, and no. 859, Giddi.

Holotype (U.S.N.M. P4183) from sample no. 859, Lower Eocene, Giddi.

#### **Anomalina pseudoacuta** Nakkady

Plate 6, figure 21

*Anomalina pseudoacuta* NAKKADY, 1950, Jour. Pal., vol. 24, p. 691, pl. 90, figs. 29-32. — LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 18, pl. 3, figs. 29-31.

A large number of specimens of this species were found in a number of samples from both Nekhl (samples 6, 7 and 8) and Giddi (samples 833, 834, 835, 837, 838, 839, 840, 842 and 843).

This species is characterized by its well-developed dorsal umbilicus, the downward flare of the last chamber on the ventral side, and the limbate sutures.

Hypotype (U.S.N.M. P4184) from sample 6.

#### **Anomalina umbonifera** (Schwager)

Plate 6, figure 17

*Anomalina umbonifera* (Schwager). — LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 18, pl. 7, figs. 15-17.

Specimens that resemble this species as recorded by LeRoy are known from samples no. 838, 840 and 842,

## SAID AND KENAWY

Giddi. The presence of this species in our material extends its range from the Danian to the Lower Eocene.

Hypotype (U.S.N.M. P4185) from sample 842.

### Genus ANOMALINOIDES Brotzen, 1942

#### **Anomalinoides nakkadyi** Said and Kenawy, new species Plate 7, figure 1

Test biconvex, umbililate; periphery strongly rounded, strongly lobulate; chambers distinct, inflated, six in last-formed whorl; sutures distinct, depressed; wall rough, with many perforations; aperture a long interiomarginal slit extending to the dorsal umbilicus.

This species is characterized by its deep and wide umbilicus, few and inflated chambers, and rough surface.

A large number of specimens of this species were found in sample no. 21, Nekhl (Chalk, Maestrichtian). It has not been recorded at higher levels, and may be an index for this zone.

Holotype (U.S.N.M. P4186) from sample no. 21, Maestrichtian, Nekhl.

#### **Anomalinoides suturatus** Said and Kenawy, new species Plate 7, figure 2

Test compressed, biconvex, umbilicus wide and with a plug on the ventral side, small and open on the dorsal side; chambers numerous, eight to eleven in the last-formed whorl, slightly inflated; periphery rounded, lobulate; sutures distinct, slightly depressed, curved; wall smooth and with perforations ventrally; aperture a long slit at the base of the last-formed chamber, extending dorsally to the umbilicus. Diameter 0.55 mm.; thickness 0.2 mm.

This species occurs in sample no. 6 (Maestrichtian, Nekhl), from which the holotype (U.S.N.M. P4187) was taken.

#### **Anomalinoides sinaensis** Said and Kenawy, new species Plate 7, figure 3

Test biconvex, compressed, ventral and dorsal umbilical regions somewhat hollowed, more so dorsally; chambers distinct, gradually enlarging as added, slightly inflated; sutures distinct, curved, depressed; periphery slightly lobulate, sharply rounded; aperture interiomarginal but extending dorsally to the umbilicus. Diameter 0.5 mm.; thickness 0.2 mm.

This species is very similar to *Anomalina aegyptiaca* LeRoy except for the apertural characters and the more depressed dorsal umbilicus. This species is found in sample

no. 6, Nekhl, and in samples no. 833, 834, 839 and 842, Giddi.

Holotype (U.S.N.M. P4188) from sample no. 6, Maestrichtian, Nekhl.

#### **Anomalinoides vanbelleni** ten Dam and Sigal Plate 7, figure 4

*Anomalinoides vanbelleni* TEN DAM AND SIGAL, 1950, Contr. Cushman Found. Foram. Res., vol. 1, p. 36, pl. 2, fig. 26.

Typical specimens of this North African Dano-Montian species were found in the Danian and Paleocene samples no. 839, 840, 842 and 852, Giddi.

Hypotypes (U.S.N.M. P4189) from sample 852.

### Subfamily CIBICIDINAE

#### Genus CIBICIDES Montfort, 1808

#### **Cibicides** cf. **C. abudurbensis** Nakkady Plate 7, figure 7

*Cibicides abudurbensis* NAKKADY, 1950, Jour. Pal., vol. 24, p. 691, pl. 90, figs. 35-38.

A number of specimens that fit Nakkady's descriptions and measurements were found in samples no. 7 and 11, Nekhl, and no. 837, 839 and 842, Giddi.

Figured specimen (U.S.N.M. P4190) from sample 11.

#### **Cibicides** cf. **C. beaumontianus** (d'Orbigny) Plate 7, figure 5

*Cibicides beaumontianus* (d'Orbigny). — BROTZEN, 1936, Sver. Geol. Unders., ser. C, no. 396, p. 188. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 160, pl. 65, fig. 12.

Specimens that resemble those recorded by Cushman from the Navarro group of the Gulf Coast region are recorded from the Danian sample no. 840, Giddi. Our specimens differ slightly in having no limbate sutures in the earlier part of the evolute dorsal side.

Figured specimen (U.S.N.M. P4191) from sample 840.

#### **Cibicides farafraensis** LeRoy Plate 7, figure 6

*Cibicides farafraensis* LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 24, pl. 10, figs. 1-3.

Specimens that seem to belong to this species were found in the Lower Eocene sample no. 859, Giddi. This species agrees in its vertical distribution with LeRoy's record in Farafra, and may be an index fossil for this age. Our specimens have a less rounded periphery and a less punctate wall.

Hypotype (U.S.N.M. P4192) from sample 859.

## FORAMINIFERA FROM SINAI

### **Cibicides loeblichii** Said and Kenawy, new species Plate 7, figure 11

Test trochoid, planoconvex; dorsal side flattened or very slightly convex, evolute; ventral side convex, involute, umbilicate; periphery rounded; chambers distinct, about eleven or twelve in the last-formed whorl, very slightly inflated; sutures distinct, depressed, very slightly curved; wall smooth, with fine perforations; aperture a slit on the periphery. Diameter 0.5 mm.; thickness 0.15 mm.

This species can be recognized by its more or less compressed test, rounded periphery, numerous chambers, and umbilicate ventral side. This species is found in sample no. 8, Nekhl (Paleocene, lower Esna shale). The holotype (U.S.N.M. P4193) comes from this sample.

### **Cibicides nekhlianus** Said and Kenawy, new species Plate 7, figure 9

Test trochoid, planoconvex; dorsal side flattened or slightly convex, evolute; ventral side convex, involute; periphery rounded to acute, circular in outline; chambers distinct, usually ten in the adult whorl, increasing gradually in size as added; sutures distinct, usually thickened on the ventral side by the deposition of shell matter, depressed or flush on the dorsal side; umbo distinct on the ventral side; wall smooth, slightly thickened above the sutures in the center of the ventral side; aperture a slit at the periphery of the last-formed chamber. Diameter 0.55 mm.; thickness 0.2 mm.

This species may be recognized by its strong ventral umbo and shell deposits in the central part of the ventral sutures. It occurs in samples no. 6, Nekhl, and no. 837, Giddi.

Holotype (U.S.N.M. P4195) from sample no. 6, Maestrichtian, Nekhl.

### **Cibicides megaloperforatus** Said and Kenawy, new species Plate 7, figure 13

Test trochoid, planoconvex, usually buckled; dorsal side flattened or slightly concave, evolute; ventral side, strongly convex, involute; periphery acute, lobulate; chambers distinct, usually five or six in the last-formed whorl, inflated on the ventral side, increasing rather rapidly in size as added, last chamber strongly inflated and elongate; sutures slightly curved, depressed, distinct; wall smooth, strongly perforate; aperture a slit extending dorsally. Diameter 0.5 mm.; thickness 0.2 mm.

This species is a characteristic one. It has an oval outline and a strongly perforate and corrugated test. It is close to *Cibicides ribbingi* Brotzen but differs in having a perforate test and more chambers. It occurs in sample no. 8,

Paleocene, lower Esna shale, Nekhl. The holotype (U.S.N.M. P4196) comes from this sample. The characters of this species show its sessile habitat.

### **Cibicides praecursorius** (Schwager) Plate 7, figure 8

*Cibicides praecursorius* (Schwager).—CUSHMAN AND TODD, 1946, Contr. Cushman Lab. Foram. Res., vol. 22, p. 65, pl. 11, figs. 20-21. —LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 25, pl. 10, figs. 12-14.

A large number of specimens of this species were found in many samples. This species, originally described from the Lower Eocene, is here recorded from deposits as old as the Maestrichtian (samples no. 6 and 8, Nekhl, and no. 833, 834, 837, 839, 840, 842 and 852, Giddi). This species may attain a large size, and is easily recognized by its smooth shell and few, inflated chambers.

Hypotypes (U.S.N.M. P4197) from sample 837.

### **Cibicides schwageri** Said and Kenawy, new species Plate 7, figure 10

Test trochoid, planoconvex; dorsal side flattened, evolute; ventral side strongly convex, involute; periphery acute, rounded; chambers distinct, usually seven or eight in the adult whorl, slightly inflated on the ventral side, increasing gradually in size as added; sutures distinct, depressed, slightly curved; wall smooth, thin, and without distinct perforations; aperture a low opening extending from the periphery across the dorsal side. Diameter 0.25 mm.; thickness 0.1 mm.

This species is common in many of the Danian samples of Giddi.

Holotype (U.S.N.M. P4198) from sample no. 840, Esna shale, Danian, Giddi.

### **Cibicides tappanae** Said and Kenawy, new species Plate 7, figure 12

Test trochoid, planoconvex; dorsal side very slightly convex, evolute; ventral side strongly convex, involute; periphery acute, rounded in outline; chambers distinct, usually seven to nine in the last-formed whorl, increasing gradually in size as added; sutures indistinct, depressed; wall smooth, coarsely perforate, particularly on the dorsal side; aperture a low slit on the periphery. Diameter 0.4 mm.; thickness 0.25 mm.

This species may be recognized by its somewhat biconvex test and perforate dorsal side, and by its very small ventral boss and indistinct sutures. It was found in samples no. 833, 834, 835 and 842, Giddi.

Holotype (U.S.N.M. P4199) from sample no. 835, Esna shale, Maestrichtian, Giddi.

## SAID AND KENAWY

### Genus *CIBICIDOIDES* Thalmann, 1939

#### *Cibicidoides libycus* (LeRoy) Plate 7, figure 17

*Cibicides libycus* LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 24, pl. 5, figs. 1-3.

Numerous typical specimens of this species are recorded from many samples from both sections: no. 7, 8 and 9, Nekhl, and no. 833, 834, 835, 837, 839, 842, 843, 848 and 852, Giddi. This species was reported in small numbers by LeRoy from the Farafra Lower Eocene, but in Sinai it seems to occur more frequently in older sediments. This species closely resembles *Cibicidoides proprius* Brotzen, known from the Swedish Paleocene. A study of the types is necessary in order to decide whether or not LeRoy's species should be suppressed.

Hypotype (U.S.N.M. P4200) from sample 837.

### Subfamily PLANULININAE

#### Genus *PLANULINA* d'Orbigny, 1826

#### *Planulina multifaria mellahensis* (Nakkady) Plate 7, figure 18

*Cibicides multifaria* (Schwager) var. *mellahensis* NAKKADY, 1950, Jour. Pal., vol. 24, p. 692, pl. 90, figs. 42-45.

A large number of specimens of this variety were found in samples no. 7, Nekhl, and no. 837, 838 and 842, Giddi. This variety may be an index fossil for the Egyptian Danian.

Hypotype (U.S.N.M. P4201) from sample 837.

### Family NONIONIDAE

#### Subfamily NONIONINAE

#### Genus *NONIONELLA* Cushman, 1926

#### *Nonionella* sp. Plate 7, figure 21

Test medium-sized, compressed, equally biconvex but not symmetrically developed; periphery rounded and evenly curved; chambers about twelve in the last-formed whorl, rapidly lengthening, gently inflated, somewhat punctate; sutures distinct, depressed or flush, somewhat curved; umbilicus on dorsal side small, narrow, depressed, shallow; on ventral side umbilical portion filled with the successive extensions of the chambers filling the depression irregularly; aperture a low slit on the periphery at the base of the last chamber. Diameter 0.55 mm.; thickness 0.2 mm.

A single specimen of this species (figured specimen, U.S.N.M. P4202) was found in sample no. 11, Nekhl. A specific determination is not possible.

### Genus *PULLENIA* Parker and Jones, 1862

#### *Pullenia* cf. *P. coryelli* White Plate 7, figure 24

*Pullenia coryelli* WHITE, 1929, Jour. Pal., vol. 3, p. 56, pl. 5, fig. 22. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 147, pl. 60, figs. 10-11.

A number of specimens that seem to belong to this species are known from the Danian sample no. 840, Giddi. This species is typically developed in Mexico and Trinidad. Our specimens are smaller than the typical form.

Figured specimen (U.S.N.M. P4203) from sample 840.

#### *Pullenia jarvisi* Cushman Plate 7, figure 28

*Pullenia jarvisi* CUSHMAN, 1936, Contr. Cushman Lab. Foram. Res., vol. 12, p. 77, pl. 13, fig. 6a-b. — CUSHMAN, 1946, U. S. Geol. Survey, Prof. Paper 206, p. 147, pl. 60, fig. 15.

Specimens that seem to belong to this Trinidad Paleocene species are known from Sinai in the contemporaneous samples no. 7 and 11, Nekhl. Our specimens are slightly more depressed, but not as greatly as *Pullenia coryelli*.

Hypotype (U.S.N.M. P4204) from sample 11.

#### *Pullenia reussi* Cushman and Todd Plate 7, figure 22

*Pullenia reussi* CUSHMAN AND TODD, 1943, Contr. Cushman Lab. Foram. Res., vol. 19, p. 4, pl. 1, figs. 10-13.

A large number of specimens of this species occur in the Paleocene samples no. 9 and 11, Nekhl, and no. 859, Giddi. This is a characteristic species, with a broadly rounded periphery, few chambers, depressed sutures, and a low, convex, apertural face.

This species was originally described from the Upper Cretaceous of Germany, but it is also recorded from the Eocene of Europe.

Hypotype (U.S.N.M. P4205) from sample 11.

#### *Pullenia quaternaria* (Reuss) Plate 7, figure 19

*Nonionina quaternaria* REUSS, 1851, Haidinger's Nat. Abhandl., vol. 4, pt. 1, p. 34, pl. 3, fig. 13.

*Pullenia quaternaria* (Reuss). — CUSHMAN AND TODD, 1943, Contr. Cushman Lab. Foram. Res., vol. 19, p. 2, pl. 1, figs. 1-4.

A number of specimens of this species were found in samples no. 837, 838, 839, and 842, Giddi. This species resembles *Pullenia reussi* but is compressed and has a fifth chamber developed on the umbilical portion of the test. This species occurs at a slightly higher level in our

## FORAMINIFERA FROM SINAI

material (Danian) than in Germany, but always occurs below the beds with *Pullenia reussi*.

Hypotype (U.S.N.M. P4206) from sample 839.

### ***Pullenia quinqueloba angusta* Cushman and Todd** Plate 7, figure 23

*Pullenia quinqueloba* Reuss var. *angusta* CUSHMAN AND TODD, 1943, Contr. Cushman Lab. Foram. Res., vol. 19, p. 10, pl. 2, figs. 3-4.

Typical specimens of this small and somewhat narrow variety were found in the Paleocene and Lower Eocene samples no. 9 and 11, Nekhl, and no. 843, 852 and 859, Giddi. This form was originally described from the Midway of Texas, but it is also known from Mexico, England and France. Records of *P. quinqueloba* Reuss in Egypt in comparable strata may belong here.

Hypotype (U.S.N.M. P4214) from sample 843.

### Genus CHILOSTOMELLA Reuss, 1850

#### ***Chiostomella czjzeki* Reuss** Plate 7, figure 16

*Chiostomella czjzeki* REUSS, 1850, Denkschr. K. Akad. Wiss. Wien, vol. 1, p. 380, pl. 48, fig. 12. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 23, pl. 8, fig. 19.

Typical specimens of this species were found in sample no. 8, Nekhl.

Hypotype (U.S.N.M. P4207) from sample 8.

### Family GLOBIGERINIDAE

#### Subfamily GLOBIGERININAE

### Genus GLOBIGERINA d'Orbigny, 1826

#### ***Globigerina bulloides* d'Orbigny** Plate 7, figure 26

*Globigerina bulloides* d'Orbigny. — CUSHMAN, 1941, Contr. Cushman Lab. Foram. Res., vol. 17, p. 38, pl. 10, figs. 1-13.

Specimens that may belong to this species are ubiquitous in the Danian, Paleocene and Lower Eocene samples of both sections. These specimens have an inflated last chamber and are more spinous than d'Orbigny's record.

Hypotype (U.S.N.M. P4208) from sample 7.

#### ***Globigerina linaperta* Finlay** Plate 7, figure 27

*Globigerina linaperta* Finlay. — BRONNIMANN, 1952, Bull. Amer. Pal., vol. 34, no. 143, p. 16, pl. 2, figs. 7-9.

A number of specimens that seem to belong to this species are known from the Danian and Paleocene samples of both sections.

Hypotypes (U.S.N.M. P4209) from sample 11.

#### ***Globigerina pseudotriloba* White** Plate 7, figure 25

*Globigerina pseudotriloba* White. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 31, pl. 9, fig. 27.

A number of specimens of this species were found in the Danian samples of Nekhl and the Paleocene of Giddi.

Hypotype (U.S.N.M. P4210) from sample 7.

#### ***Globigerina subcretacea* Łomnicki** Plate 7, figure 31

*Globigerina subcretacea* Łomnicki. — LEROY, 1953, Geol. Soc. Amer., Mem. 54, p. 32, pl. 9, figs. 4-5.

Typical specimens of this species were found to be abundant in the Maestrichtian of Nekhl and the Paleocene of Giddi.

Hypotypes (U.S.N.M. P4211) from sample 834.

### Genus RUGOGLOBIGERINA Bronnimann, 1952

#### ***Rugoglobigerina "cretacea* Cushman** of Bermudez, 1952

Plate 7, figure 30

"*Rugoglobigerina cretacea* Cushman (non *Globigerina cretacea* d'Orbigny)." — BERMUDEZ, 1952, Venezuela, Minist. Minas e Hidrocarb., Bol. Geol., vol. 2, no. 4, pl. 22, fig. 3 (after Cushman, 1931).

*Globigerina cretacea* d'Orbigny. — CUSHMAN, 1931 (part), Tennessee, Div. Geol., Bull. 41, p. 58, pl. 10, fig. 7a-c (non fig. 6).

A number of specimens that seem to belong to this species were found in the Danian of Nekhl. Our specimens have more inflated chambers than Cushman's form, but resemble that species in apertural characters, ornamentation and general form.

Hypotype (U.S.N.M. P4212) from sample 7.

#### ***Rugoglobigerina esnehensis* (Nakkady)** Plate 7, figure 29

*Globigerina cretacea* d'Orbigny var. *esnehensis* NAKKADY, 1950, Jour. Pal., vol. 24, p. 689, pl. 90, figs. 14-16.

A number of specimens that belong to this species are known from the Danian and Paleocene samples of Nekhl and Giddi. In our material it is associated with *Rugoglobigerina "cretacea,"* and it therefore seems advisable to give this form specific rank.

Hypotype (U.S.N.M. P4213) from sample 7.

## SAID AND KENAWY

### BIBLIOGRAPHY

ANSARY, S. E.  
1955 - *The foraminiferal fauna from the Upper Eocene of Egypt*. Geol. Soc. Egypt, Abstr. Proc., vol. 1, p. 20.

BALL, J.  
1939 - *Contributions to geography of Egypt*. Cairo: Geological Survey of Egypt.

BANDY, O. L.  
1952 - *The genotype of Siphogenerina*. Cushman Found. Foram. Res., Contr., vol. 3, pp. 17-18.

BANDY, O. L., AND BURNSIDE, R. J.  
1951 - *The genus Siphogenerina Schlumberger*. Ibid., vol. 2, pp. 13-15.

BARRON, T.  
1907 - *The topography and geology of the Peninsula of Sinai (western portion)*. Cairo: Geological Survey of Egypt.

BARTENSTEIN, H.  
1948 - *Entwicklung der Gattung Lenticulina (Lenticulina) Lamarck 1804 mit ihrem Unter-Gattungen (For.)*. Senckenbergiana, vol. 29, pp. 41-65.

1949 - *Neoflabellina, nomen novum pour Flabellina d'Orbigny 1839 (foraminifères)*. Soc. Géol. France, C. R. Somm., no. 9, pp. 164-166.

BEADNELL, H. J. L.  
1927 - *The wilderness of Sinai*. London: Arnold.

BERMUDEZ, P. J.  
1952 - *Estudio sistemático de los foraminíferos rotaliformes*. Venezuela, Minist. Minas e Hidrocarb., Bol. Geol., vol. 2, no. 4.

BOLLI, H.  
1951 - *The genus Globotruncana in Trinidad*, B.W.I. Jour. Pal., vol. 25, pp. 187-199.

BOUSSAC, J.  
1913 - *Observations nouvelles sur le Nummulitique de la Haute-Égypte*. Soc. Géol. France, C. R. Somm., no. 7, pp. 63-65; no. 11, pp. 109-110.

BRONNIMANN, P.  
1952 - *Micropaleontologic literature 1941-1951 on Trinidad, Tobago and Barbados*, B.W.I. The Micropaleontologist, vol. 6, no. 1, pp. 23-42.

BROTZEN, F.  
1942 - *Die Foraminiferengattung Gavelinella und die Systematik der Rotaliformes*. Sweden, Sver. Geol. Unders., Avh., ser. C, no. 451, pp. 5-60.  
1948 - *The Swedish Paleocene and its foraminiferal fauna*. Ibid., ser. C, no. 493, pp. 3-140.  
1950 - *Methods and technique in routine work*. The Micropaleontologist, vol. 4, no. 2, pp. 18-20.  
1953 - *Problems in the nomenclature of the foraminifera*. Ibid., vol. 7, no. 2, pp. 35-38.

CROWLEY, A. J.  
1952 - *Method of extracting foraminifera from refractory shale*. Amer. Assoc. Petr. Geol., Bull., vol. 36, p. 2185.

CUSHMAN, J. A.  
1946 - *Upper Cretaceous foraminifera of the Gulf Coastal region of the United States and adjacent areas*. U. S. Geol. Survey, Prof. Paper no. 206.  
1947 - *Foraminiferal evidence for the age of the Velasco shale of Mexico and the Lizard Springs marl of Trinidad*. Jour. Pal., vol. 21, p. 587.  
1949 - *The foraminiferal fauna of the Upper Cretaceous Arkadelphia marl*. U. S. Geol. Survey, Prof. Paper no. 221-A, pp. 1-19.  
1951 - *Paleocene foraminifera of the Gulf Coastal region and adjacent areas*. Ibid., no. 232, pp. 1-75.

CUSHMAN, J. A., AND RENZ, H. H.  
1948 - *The foraminiferal fauna of the Lizard Springs formation of Trinidad, British West Indies*. Cushman Lab. Foram. Res., Spec. Publ. no. 18, pp. 1-48.  
1948 - *Eocene foraminifera of the Navet and Hospital Hill formations of Trinidad*, B.W.I. Ibid., no. 24, pp. 1-42.

CUVILLIER, J.  
1930 - *Révision du Nummulitique égyptien*. Inst. Égypte, Mém., vol. 16, pp. 1-371.  
1949 - *Présence du Paléocène en Haute-Égypte*. Soc. Géol. France, C. R. Somm., no. 12, pp. 269-270.

CUVILLIER, J., AND SZAKALL, V.  
1948 - *Évolution du genre Globorotalia dans l'Éocène en Aquitaine occidentale*. Ibid., no. 3-4, pp. 81-83.

DAM, A. TEN, AND SIGAL, J.  
1950 - *Some new species of foraminifera from the Dano-Montian of Algeria*. Cushman Found. Foram. Res., Contr., vol. 1, pp. 31-37.

DROOGER, C. W.  
1952 - *Foraminifera from Cretaceous-Tertiary transitional strata of the Hodna Mountains, Algeria*. Ibid., vol. 3, pp. 89-102.

FARIS, M. I.  
1947 - *The contact of the Cretaceous and Eocene rocks in the Tramsa-Tukh area (Quena; Upper Egypt)*. Inst. Égypte, Bull., vol. 28, pp. 73-85.

FRAENKE, A.  
1928 - *Die Foraminiferen der Oberen Kreide Nord- und Mitteldeutschlands*. Preuss. Geol. Landesanst., Abh., new ser., no. 111, pp. 1-207.

FREZZELL, D. L.  
1954 - *Handbook of Cretaceous foraminifera of Texas*. Texas, Univ., Bur. Econ. Geol., Rept. Invest. no. 22, pp. 1-232.

GALLOWAY, J. J.  
1933 - *Manual of foraminifera*. Bloomington, Indiana: Principia Press.

GLAESSNER, M. F.  
1945 - *Principles of micropalaeontology*. Melbourne: Melbourne University Press, 296 pp.

GRABAU, A. W.  
1924 - *Principles of stratigraphy*. New York: A. G. Seiler and Co.

GRIMSDALE, T. F.  
1947 - *Upper Cretaceous foraminifera; a criticism*. Jour. Pal., vol. 21, pp. 586-587.

HENSON, F. R. S.  
1938 - *Stratigraphical correlation by small foraminifera in Palestine and adjoining countries*. Geol. Mag., vol. 75, pp. 227-233.

HILTERMANN, H.  
1952 - *Stratigraphische Fragen des Campan und Maastricht unter besonderer Berücksichtigung der Mikropaläontologie*. Geol. Jahrb., vol. 67, pp. 47-66.

## FORAMINIFERA FROM SINAI

HILTERMANN, H., AND KOCH, W.  
1950 - *Taxonomie und Vertikalverbreitung von Bolivinoides-Arten im Senon Nordwestdeutschlands*. *Ibid.*, vol. 64, pp. 595-632.

HÖGLUND, H.  
1947 - *Foraminifera of the Gullmar Fjord and the Skagerak*. Uppsala, Univ., Zool. Bidrag, vol. 26, pp. 3-328.

HOEKER, J.  
1951 - *The foraminifera of the Siboga Expedition; Part III*. Siboga-Exped., Monogr., no. 4b, pp. 1-513.

LEROUX, L. W.  
1953 - *Biostratigraphy of the Maifi section, Egypt*. Geol. Soc. Amer., Mem., no. 54, pp. 1-73.

LOEBLICH, A. R., JR.  
1951 - *Cooling in Heterohelicidae*. Cushman Found. Foram. Res., Contr., vol. 2, pp. 106-110.

MALKIN, D. S., AND JUNG, D. A.  
1941 - *Marine sedimentation and oil accumulation on the Gulf Coast; 1 - Progressive marine overlap*. Amer. Assoc. Petr. Geol., Bull., vol. 25, pp. 2010-2020.

MALKIN, D. S., AND ECHOLS, D. J. [JUNG, D. A.]  
1948 - *Marine sedimentation and oil accumulation; 2 - Progressive marine offlap and overlap-offlap*. *Ibid.*, vol. 32, pp. 252-261.

MARIE, P.  
1941 - *Les foraminifères de la Craie: Les foraminifères de la Craie à Belemnites mucronata du Bassin de Paris*. Paris, Mus. Nat. Hist. Nat., Mém., new ser., vol. 12, fasc. 1, pp. 1-296.  
1949 - *Microfaunes pélagiques des couches à Cardita beaumonti*. Soc. Géol. France, C. R. Somm., no. 12, pp. 241-243.

NAKKADY, S. E.  
1950 - *A new foraminiferal fauna from the Esna shales and Upper Cretaceous Chalk of Egypt*. Jour. Pal., vol. 24, pp. 675-692.  
1951 - *Zoning the Mesozoic-Cenozoic transition of Egypt by the Globorotalitidae*. Farouk I Univ., Fac. Sci., Bull., no. 1, pp. 45-58.

OMARA, S. M.  
[MS.] *Micro-stratigraphical studies of the Cretaceous rocks of the Nezzazat area*. (Fouad I Univ., M.Sc. thesis, 1951.)

OSMAN, A.  
1954 - *Upper Cretaceous foraminifera of western Sinai*. Cairo Univ., Fac. Engin., Bull. (1953), pp. 335-363.

PICARD, L.  
1943 - *Structure and evolution of Palestine*. Hebrew Univ., Geol. Dept., Bull., vol. 4, nos. 2-4.

PLOEG, P. VAN DER  
1953 - *Egypt*. In: ILLING, V. C. (ed.), *The world's oilfields; the eastern hemisphere. (The Science of Petroleum, vol. 6, pt. 1.)* London - New York - Toronto: Oxford University Press.

PLUMMER, H. J.  
1931 - *Some Cretaceous foraminifera from Texas*. Texas, Univ., Bull., no. 3101, pp. 109-203.

REISS, Z.  
1954 - *Upper Cretaceous and Lower Tertiary Bolivinoides from Israel*. Cushman Found. Foram. Res., Contr., vol. 5, pp. 154-164.

RENN, H. H.  
1951 - *Remarks on the age of the Lizard Springs formation of Trinidad, B.W.I.* Cushman Found. Foram. Res., Contr., vol. 2, pp. 15-16.

REUSS, A. E.  
1860 - *Die Foraminiferen der westphälischen Kreideformation*. K. Akad. Wiss. Wien, Math.-Naturw. Cl., Sitzber., vol. 40, pp. 147-238.

SAID, R.  
1950 - *The distribution of foraminifera in the northern Red Sea*. Cushman Found. Foram. Res., Contr., vol. 1, pp. 9-29.

SAID, R., AND BARAKAT, M. G.  
[MS.] *Jurassic foraminiferal fauna from northern Sinai, Egypt* (in press).

SAID, R., AND SHUKRI, N. M.  
[MS.] *Ancient shore-lines of Egypt*. Soc. Géogr. Egypte, Bull. (in press).

SHUKRI, N. M.  
1954 - *Remarks on the geological structure of Egypt; Part 1 - Cretaceous-Eocene relations*. Soc. Géogr. Egypte, Bull., vol. 27, pp. 65-82.

SHUKRI, N. M., AND SAID, R.  
[MS.] *Remarks on the geological structure of Egypt; Part 2 - Tectonic trends*. Soc. Géogr. Egypte, Bull. (in press).

STAINFORTH, R. M.  
1951 - *Growth of recognition of the zonal value of planktonic foraminifera*. The Micropaleontologist, vol. 5, no. 4, pp. 30-32.  
1952a *Ecology of arenaceous foraminifera*. *Ibid.*, vol. 6, no. 1, pp. 42-44.  
1952b *Classification of uniserial calcareous foraminifera*. Cushman Found. Foram. Res., Contr., vol. 3, pp. 6-14.  
1952c *Nodosaria nomenclature*. *Ibid.*, vol. 3, p. 146.

STEPHENSON, L. W., AND OTHERS  
1942 - *Correlation of the outcropping Cretaceous formations of the Atlantic and Gulf Coastal Plain and Trans-Pecos Texas*. Geol. Soc. Amer., Bull., vol. 53, pp. 435-448.

STETSON, H. C.  
1949 - *The sediments and stratigraphy of the East Coast continental margin; Georges Bank to Norfolk Canyon*. Massachusetts Inst. Technol., Woods Hole Oceanogr. Inst., Papers Phys. Oceanogr., vol. 11, no. 2.

SWAIN, F. M.  
1949 - *Onlap, offlap, overstep and overlap*. Amer. Assoc. Petr. Geol., Bull., vol. 33, pp. 634-636.

TODD, R.  
1954 - *The smaller foraminifera in correlation and paleo-ecology*. Science, vol. 119, p. 448.

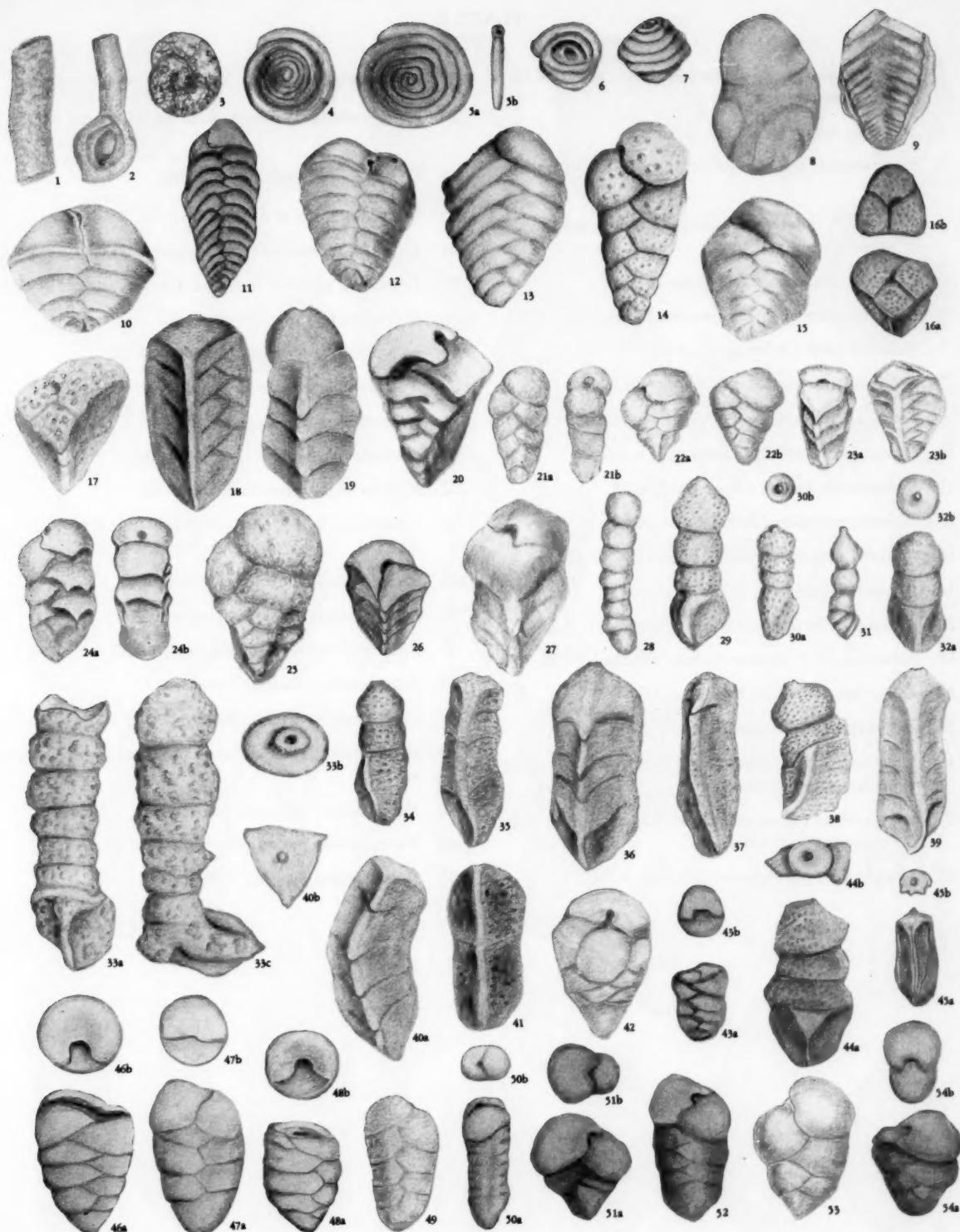
TROMMEL, S. W.  
1942 - *The microfauna of the basal-Eocene and Upper Cretaceous section of Ramandig Well No. 2 (S.E. Turkey)*. Turkey, Maden Tektik ve Arama Enstitüsü, Yayınları (Mining Research and Exploration Institute of Turkey, Publ.), pp. 113-125.  
1949 - *The determination of the Cretaceous-Eocene boundary by means of quantitative generic microfaunal determinations and the conception of Danian in the Near East*. Jour. Pal., vol. 23, pp. 673-676.  
1952 - *Tentative compilation of the micropaleontology of Egypt*. *Ibid.*, vol. 26, pp. 661-667.

ZITTEL, K. A.  
1883 - *Beiträge zur Geologie und Paläontologie der Libyschen Wüste und der angrenzenden Gebiete von Aegypten*. Paläontographica, vol. 30, pp. 96-112.

SAID AND KENAWY

PLATE 1

- 1 *Bathysiphon(?) dubia* (White),  $\times 47$ .
- 2 *Lituotuba* cf. *L. lituiformis* (H. B. Brady),  $\times 47$ .
- 3 *Haplophragmoides eggeri* Cushman,  $\times 47$ .
- 4 *Involutina cretacea* (Reuss),  $\times 32$ .
- 5 *Involutina* sp.,  $\times 65$ : a, side view; b, edge view.
- 6 *Glomospira charoides leroyi* Said and Kenawy, n. var.,  $\times 65$ .
- 7 *Glomospira gordialis* (Jones and Parker),  $\times 32$ .
- 8 *Ammobaculites schwageri* Said and Kenawy, n. sp.,  $\times 32$ .
- 9 *Spirolectammina dentata* (Alth),  $\times 32$ .
- 10 *Spirolectammina knebeli* LeRoy,  $\times 65$ .
- 11 *Spirolectammina henryi* LeRoy,  $\times 32$ .
- 12 *Spirolectammina knebeli longa* Said and Kenawy, n. var.,  $\times 65$ .
- 13 *Spirolectammina paracarinata* Said and Kenawy, n. sp.,  $\times 65$ .
- 14 *Textularia farafricensis* LeRoy,  $\times 65$ .
- 15 *Vulvulina colei* Cushman,  $\times 65$ .
- 16 *Verneuilina aegyptiaca* Said and Kenawy, n. sp.,  $\times 32$ : a, side view; b, apertural view.
- 17 *Verneuilina karreri* Said and Kenawy, n. sp.,  $\times 32$ .
- 18 *Tritaxia barakai* Said and Kenawy, n. sp.,  $\times 32$ .
- 19 *Tritaxia dubia* (Reuss),  $\times 32$ .
- 20 *Gaudryina aissana* ten Dam and Sigal,  $\times 47$ .
- 21 *Gaudryina elegantissima* Said and Kenawy, n. sp.,  $\times 47$ : a, side view; b, edge view.
- 22 *Gaudryina laevigata* Franke,  $\times 32$ : a-b, side views.
- 23 *Gaudryina limbata* Said and Kenawy, n. sp.,  $\times 32$ : a, edge view; b, side view.
- 24 *Gaudryina nekhensis* Said and Kenawy, n. sp.,  $\times 22$ : a, side view; b, edge view.
- 25 *Gaudryina* cf. *G. rugosa* d'Orbigny,  $\times 32$ .
- 26 *Gaudryina pyramidata* Cushman,  $\times 32$ .
- 27 *Gaudryina soldadoensis* Cushman and Renz,  $\times 32$ .
- 28 *Pseudoclavulina clavata* (Cushman),  $\times 32$ .
- 29 *Pseudoclavulina farafricensis* LeRoy,  $\times 32$ .
- 30 *Pseudoclavulina globulifera* ten Dam and Sigal,  $\times 32$ : a, side view; b, apertural view.
- 31 *Pseudoclavulina maqfiensis* LeRoy,  $\times 32$ .
- 32 *Pseudoclavulina amorpha* (Cushman),  $\times 32$ : a, side view; b, apertural view.
- 33 *Pseudoclavulina pseudoarenata* Said and Kenawy, n. sp.,  $\times 22$ : a, holotype; b, apertural view of paratype; c, side view of paratype.
- 34 *Clavulinoides algerianus* ten Dam and Sigal,  $\times 32$ .
- 35 *Clavulinoides disjunctus* (Cushman),  $\times 32$ .
- 36 *Clavulinoides asper* (Cushman),  $\times 32$ .
- 37 *Clavulinoides* cf. *C. cubensis* (Cushman and Bermudez),  $\times 32$ .
- 38 *Clavulinoides asper whitei* (Cushman and Jarvis),  $\times 32$ .
- 39 *Clavulinoides trilatera* (Cushman),  $\times 32$ .
- 40 *Clavulinoides trilatera concavus* (Cushman),  $\times 32$ .
- 41 *Clavulinoides guayabalensis* (Cole),  $\times 32$ .
- 42 *Arenobulimina aegyptiaca* Said and Kenawy, n. sp.,  $\times 32$ .
- 43 *Textulariella* sp.,  $\times 32$ : a, side view; b, apertural view.
- 44 *Pseudogaudryinella compacta* Said and Kenawy, n. sp.,  $\times 32$ : a, side view; b, apertural view.
- 45 *Heterostomella austinana* Cushman,  $\times 32$ : a, side view; b, apertural view.
- 46 *Marssonella oxycona trinitatis* Cushman and Renz,  $\times 32$ : a, side view; b, apertural view.
- 47 *Marssonella indentata* (Cushman and Jarvis),  $\times 32$ : a, side view; b, apertural view.
- 48 *Marssonella oxycona* (Reuss),  $\times 32$ : a, side view; b, apertural view.
- 49 *Dorothia concinna* (Reuss),  $\times 32$ .
- 50 *Marssonella ellisorae* Cushman,  $\times 32$ : a, side view; b, apertural view.
- 51 *Dorothia pontoni* Cushman,  $\times 32$ : a, side view; b, apertural view.
- 52 *Dorothia bulletta* (Carsey),  $\times 32$ .
- 53 *Dorothia pupa* (Reuss),  $\times 47$ .
- 54 *Dorothia* cf. *D. conulus* (Reuss),  $\times 32$ : a, side view; b, apertural view.



SAID AND KENAWY

PLATE 2

1 *Dorothia sinaensis* Said and Kenawy, n. sp.,  $\times 32$ : a, side view; b, edge view.

2 *Dorothia retusa* Cushman,  $\times 47$ .

3 *Hagenowella gibbosa* (d'Orbigny),  $\times 32$ : a-b, side views.

4 *Karreriella danica* (Franke),  $\times 32$ : a, side view; b, edge view.

5 *Robulus pseudocultratus* Cole,  $\times 32$ .

6 *Robulus midwayensis carinatus* (Plummer),  $\times 32$ .

7 *Robulus isidis* (Schwager),  $\times 32$ .

8 *Robulus pseudo-secans* Cushman,  $\times 32$ .

9 *Lenticulina navicula* (d'Orbigny),  $\times 32$ .

10 *Lenticulina rotulata* (Lamarck),  $\times 22$ .

11 *Robulus turbinatus* (Plummer),  $\times 32$ .

12 *Robulus münsteri* (Roemer),  $\times 32$ .

13 *Robulus pseudo-costatus* (Plummer),  $\times 32$ .

14 *Hemicristellaria* sp.,  $\times 32$ .

15 *Hemicristellaria tuberculata* (Plummer),  $\times 32$ .

16 *Astacolus* cf. *A. varians rectus* (Franke),  $\times 32$ .

17 *Astacolus calliopsis* (Reuss),  $\times 65$ .

18 *Hemicristellaria humilis* (Reuss),  $\times 32$ .

19 *Marginulinopsis comma* (Roemer),  $\times 32$ : a, side view; b, apertural view.

20 *Marginulina curvatura* Cushman,  $\times 32$ : a, side view; b, apertural view.

21 *Marginulina pachygaster* Gümbel,  $\times 32$ .

22 *Miliammina* sp.,  $\times 65$ : a, side view; b, front view.

23 *Marginulinopsis deserti* Said and Kenawy, n. sp.,  $\times 65$ .

24 *Dentalina catenula* Reuss,  $\times 32$ .

25 *Dentalina gracilis* d'Orbigny,  $\times 32$ .

26 *Dentalina communis* (d'Orbigny),  $\times 32$ .

27 *Dentalina ghorabi* Said and Kenawy, n. sp.,  $\times 22$ .

28 *Dentalina legumen* Reuss,  $\times 65$ .

29 *Dentalina basiplanata* Cushman,  $\times 32$ .

30 *Nodosaria affinis* Reuss,  $\times 22$ .

31 *Nodosaria zippei* Reuss,  $\times 22$ .

32 *Nodosaria limbata* d'Orbigny,  $\times 32$ .

33 *Nodosaria paupercula* Reuss,  $\times 22$ .

34 *Nodosaria "vertebralis" (Batsch)* of Plummer,  $\times 22$ .

35 *Frondicularia frankei* Cushman,  $\times 32$ .

36 *Frondicularia goldfussi* Reuss,  $\times 32$ .

37 *Frondicularia* cf. *F. clarki* Bagg,  $\times 32$ .

38 *Frondicularia linearis* Franke,  $\times 32$ .

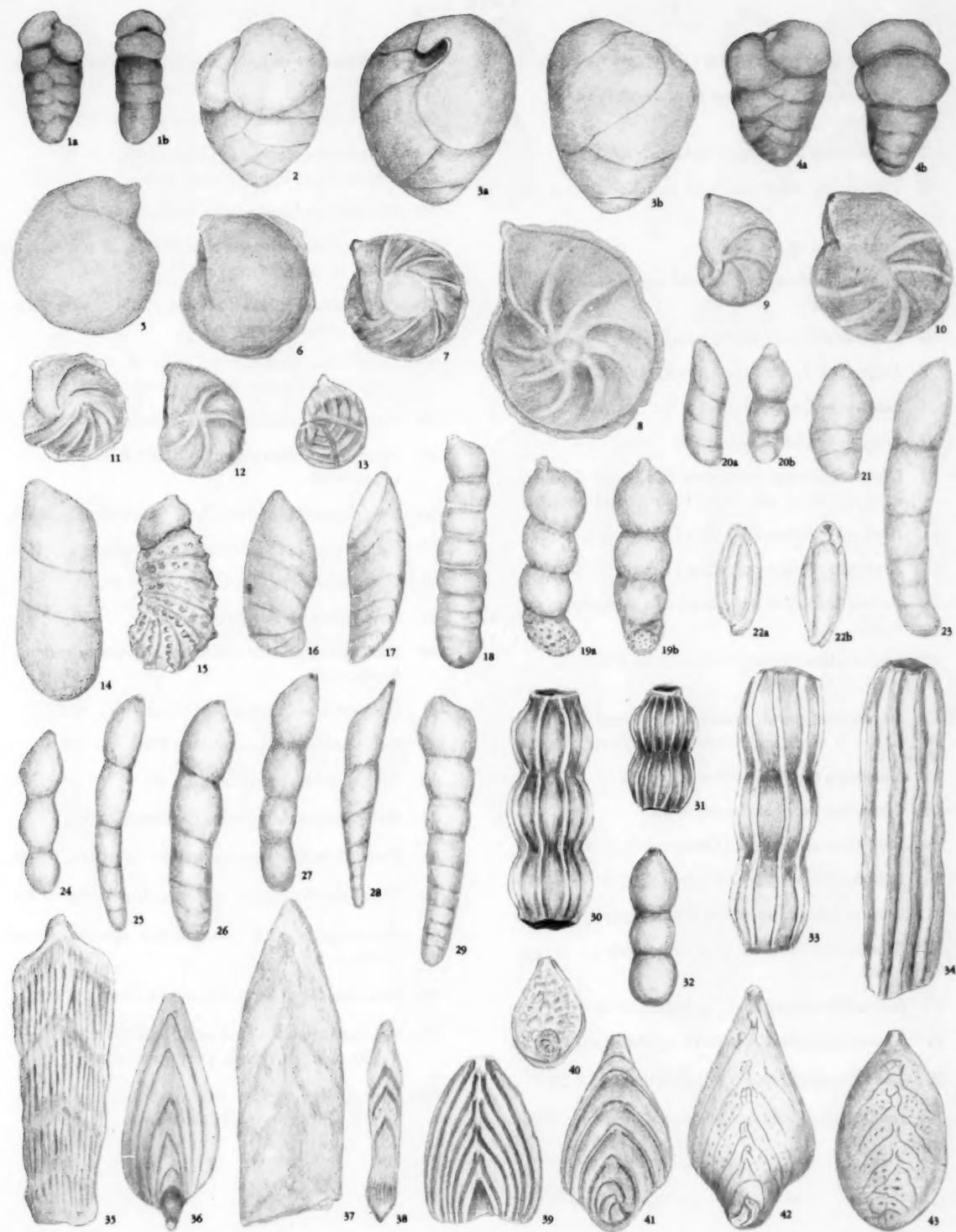
39 *Frondicularia cordata* Roemer,  $\times 32$ .

40 *Neoflabellina semireticulata* (Cushman and Jarvis),  $\times 65$ .

41 *Neoflabellina suturalis* (Cushman),  $\times 65$ .

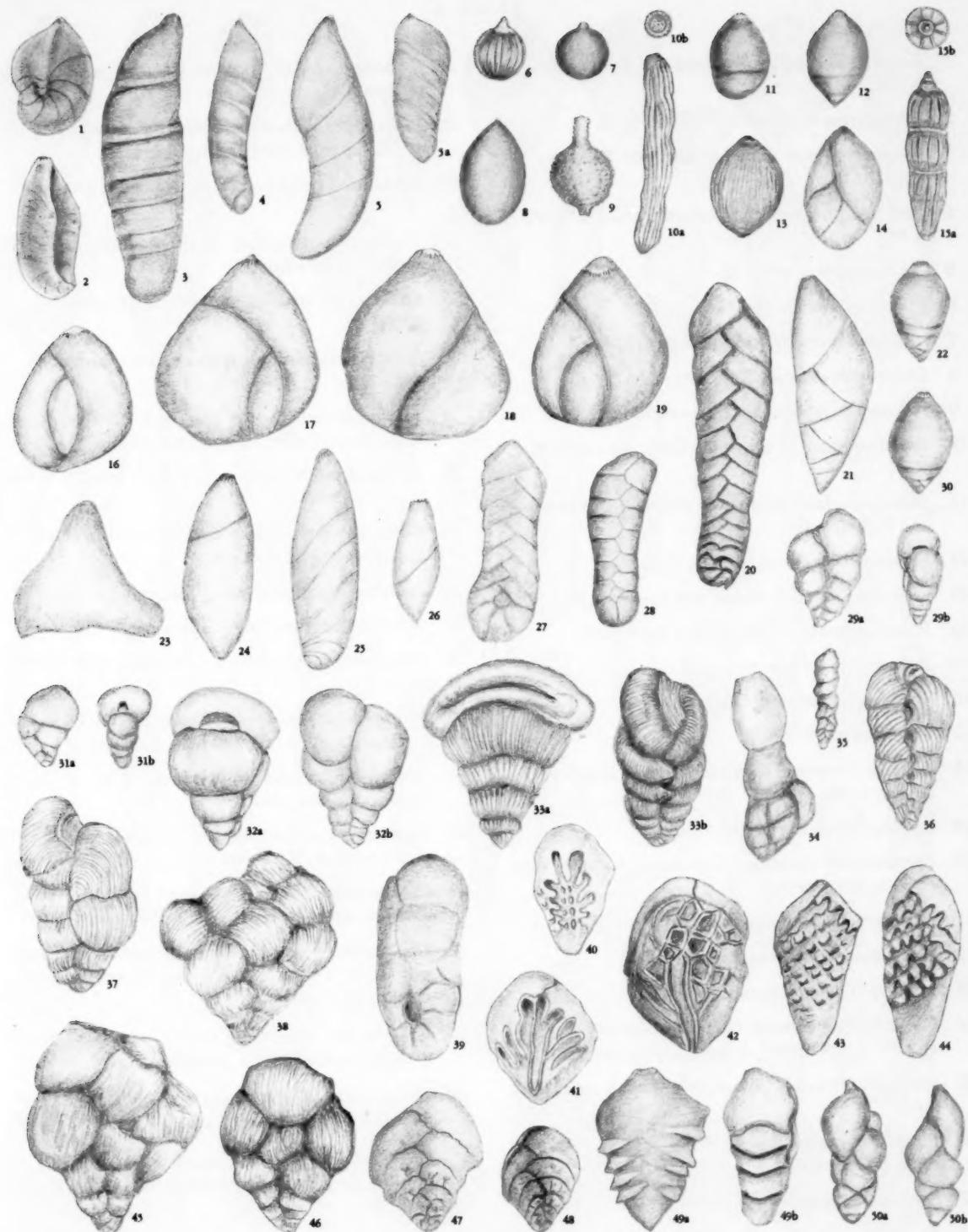
42 *Neoflabellina jarvisi* (Cushman),  $\times 47$ .

43 *Neoflabellina rugosa* (d'Orbigny),  $\times 65$ .



## PLATE 3

- 1 *Saracenaria triangularis* (d'Orbigny),  $\times 32$ .
- 2 *Saracenaria saratogana* Howe and Wallace,  $\times 32$ .
- 3 *Vaginulina taylorana* Cushman,  $\times 32$ .
- 4 *Vaginulina misrensis* Said and Kenawy, n. sp.,  $\times 32$ .
- 5 *Vaginulina* sp.,  $\times 65$ .
- 5a *Vaginulina longiformis* Said and Kenawy, n. sp.,  $\times 32$ .
- 6 *Lagena sulcata* (Walker and Jacob),  $\times 32$ .
- 7 *Lagena* cf. *L. globosa* (Montagu),  $\times 32$ .
- 8 *Lagena apiculata* Reuss,  $\times 32$ .
- 9 *Lagena hispida* Reuss,  $\times 32$ .
- 10 *Chrysalogonium tappanae* Said and Kenawy, n. sp.,  $\times 32$ : a, side view; b, apertural view.
- 11 *Rectoglandulina bistegia* (Olszewski),  $\times 32$ .
- 12 *Rectoglandulina pygmaea* (Reuss),  $\times 32$ .
- 13 *Rectoglandulina bulla* Said and Kenawy, n. sp.,  $\times 32$ .
- 14 *Eoguttulina anglica* Cushman and Ozawa,  $\times 32$ .
- 15 *Lagenonodosaria sinaensis* Said and Kenawy, n. sp.,  $\times 65$ : a, side view; b, apertural view.
- 16 *Guttulina trigonula* (Reuss),  $\times 32$ .
- 17-18 *Globulina lacrima* Reuss,  $\times 32$ .
- 19 *Guttulina adhaerens* (Olszewski),  $\times 32$ .
- 20 *Bolivinopsis clotho* (Grzybowski),  $\times 32$ .
- 21 *Pyrulinoides acuminatus* (d'Orbigny),  $\times 32$ .
- 22 *Glandulina antiqua* Said and Kenawy, n. sp.,  $\times 32$ .
- 23 *Ramulina navarroana* Cushman,  $\times 32$ .
- 24 *Enantiomorphina lemoinei inflata* Marie,  $\times 65$ .
- 25 *Enantiovaginulina recta* (d'Orbigny),  $\times 65$ .
- 26 *Enantiomorphina lemoinei conica* Marie,  $\times 65$ .
- 27 *Bolivinopsis minuta* Said and Kenawy, n. sp.,  $\times 130$ .
- 28 *Bolivinopsis rosula* (Ehrenberg),  $\times 32$ .
- 29 *Gümbelina globulosa* (Ehrenberg),  $\times 65$ : a, side view; b, peripheral view.
- 30 *Glandulina laevigata* (d'Orbigny),  $\times 32$ .
- 31 *Gümbelina ultimatumida* White,  $\times 65$ : a, side view; b, peripheral view.
- 32 *Gümbelina reussi* Cushman,  $\times 65$ : a, side view; b, peripheral view.
- 33 *Gümbelina plummerae* Loetterle,  $\times 65$ : a, peripheral view; b, side view.
- 34 *Rectogümbelina cretacea* Cushman,  $\times 130$ .
- 35 *Rectogümbelina longa* Said and Kenawy, n. sp.,  $\times 65$ .
- 36 *Pseudogümbelina excolata* (Cushman),  $\times 65$ .
- 37 *Pseudogümbelina striata* (Ehrenberg),  $\times 65$ .
- 38 *Ventilabrella eggeri* Cushman,  $\times 65$ .
- 39 *Lacosteina* cf. *L. gouskovi* Marie,  $\times 130$ .
- 40 *Bolivinoides draco miliaris* Hiltermann and Koch,  $\times 65$ .
- 41 *Bolivinoides draco draco* (Marsson),  $\times 47$ .
- 42 *Bolivinoides draco dorreeni* Finlay,  $\times 65$ .
- 43 *Bolivinoides curtus* Reiss,  $\times 65$ .
- 44 *Bolivinoides delicatus* Cushman,  $\times 65$ .
- 45 *Planoglobulina acervulinoides* (Egger),  $\times 65$ .
- 46 *Ventilabrella eggeri glabrata* Cushman,  $\times 65$ .
- 47 *Bolivinoides* cf. *B. trinitatensis* Cushman and Jarvis,  $\times 130$ .
- 48 *Bolivinoides semireticulatus* (LeRoy),  $\times 65$ .
- 49 *Bolivinita bandyi* Said and Kenawy, n. sp.,  $\times 130$ : a, side view; b, peripheral view.
- 50 *Eouvigerina hofkeri* Said and Kenawy, n. sp.,  $\times 130$ : a, front view; b, side view.



## SAID AND KENAWY

## PLATE 4

1 *Zeauvigerina aegyptiaca* Said and Kenawy, n. sp.,  $\times 130$ .

2 *Eouvigerina aegyptiaca* Nakkady,  $\times 65$ .

3 *Pseudouvigerina sinaensis* Said and Kenawy, n. sp.,  $\times 65$ .

4 *Orthomorphina rohri* (Cushman and Stainforth),  $\times 65$ .

5 *Orthomorphina* sp.,  $\times 65$ .

6 *Buliminella laevis* (Beissel),  $\times 32$ .

7 *Buliminella cushmani* Sandidge,  $\times 32$ .

8 *Buliminella carseyae* Plummer,  $\times 65$ .

9 *Buliminella fabilis* Cushman and Parker,  $\times 65$ .

10 *Bulimina reussi navarroensis* Cushman and Parker,  $\times 65$ .

11 *Bulimina arkadelphiana midwayensis* Cushman and Parker,  $\times 65$ .

12 *Bulimina kickapooensis* Cole,  $\times 32$ .

13 *Bulimina prolixa* Cushman and Parker,  $\times 65$ .

14 *Bulimina stokesi* Cushman and Renz,  $\times 65$ .

15 *Bulimina reussi* Morrow,  $\times 65$ .

16 *Virgulina navarroana* Cushman,  $\times 65$ .

17 *Virgulina* sp.,  $\times 32$ .

18 *Bolivina decurrens parallela* Said and Kenawy, n. var.,  $\times 65$ .

19 *Bolivina incrassata* Reuss,  $\times 32$ .

20 *Loxostomum clavatum* (Cushman),  $\times 32$ : a, side view; b, front view.

21 *Loxostomum limonense* (Cushman),  $\times 65$ .

22 *Loxostomum minutissimum* Cushman,  $\times 130$ .

23 *Loxostomum tegulatum* (Reuss),  $\times 130$ .

24 *Rectuvigerina advena* Said and Kenawy, n. sp.,  $\times 130$ : a, front view; b, apertural view.

25 *Siphogenerina* sp.,  $\times 32$ : a, side view; b, apertural view.

26 *Pleurostomella subnodosa* Reuss,  $\times 65$ : a, side view; b, front view.

27 *Nodosarella gracillima* Cushman,  $\times 32$ .

28 *Bifarina antiqua* Said and Kenawy, n. sp.,  $\times 65$ : a, front view; b, side view.

29 *Nodosarella misrensis* Said and Kenawy, n. sp.,  $\times 32$ : a, front view; b, side view.

30 *Nodosarella minuta* Said and Kenawy, n. sp.,  $\times 130$ .

31 *Nodosarella subnodosa* (Guppy),  $\times 32$ : a, side view; b, front view.

32 *Stilostomella alexanderi impensia* (Cushman),  $\times 32$ .

33 *Stilostomella alexanderi alexanderi* (Cushman),  $\times 65$ .

34 *Ellipsoglandulina ellisi* Said and Kenawy, n. sp.,  $\times 32$ : a, side view; b, apertural view.

35 *Ellipsoglandulina exponens* (Brady),  $\times 32$ : a, side view; b, front view.

36 *Ellipsoglandulina velascoensis* Cushman,  $\times 32$ : a, side view; b, front view.

37 *Stilostomella stephensonii* (Cushman),  $\times 32$ .

38 *Stilostomella horridens* (Cushman),  $\times 32$ .

39 *Stilostomella paleocenica* (Cushman and Todd),  $\times 32$ .

40 *Ellipsoidella pleurostomelloides* Heron-Allen and Earland,  $\times 32$ : a, side view; b, front view.

41 *Valvularia esneensis* Nakkady,  $\times 32$ : a, dorsal view; b, ventral view.

42 *Valvularia scrobiculata* (Schwager),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.

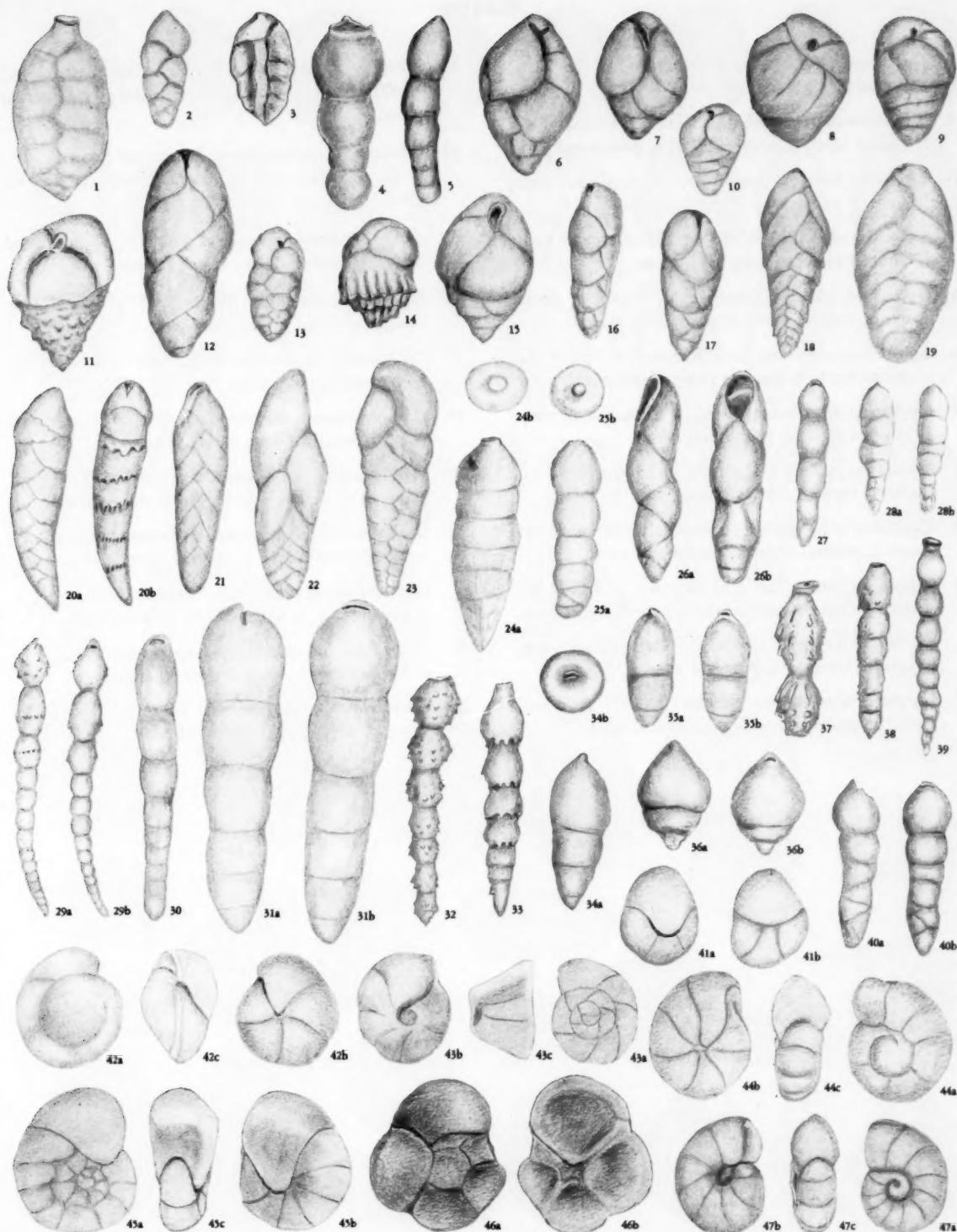
43 *Globorotalites conicus* (Carsey),  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.

44 *Gavelinella brotzeni paleocenica* Said and Kenawy, n. var.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.

45 *Valvularia aegyptiaca* LeRoy,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.

46 *Globorotalia membranacea* (Ehrenberg),  $\times 65$ : a, dorsal view; b, ventral view.

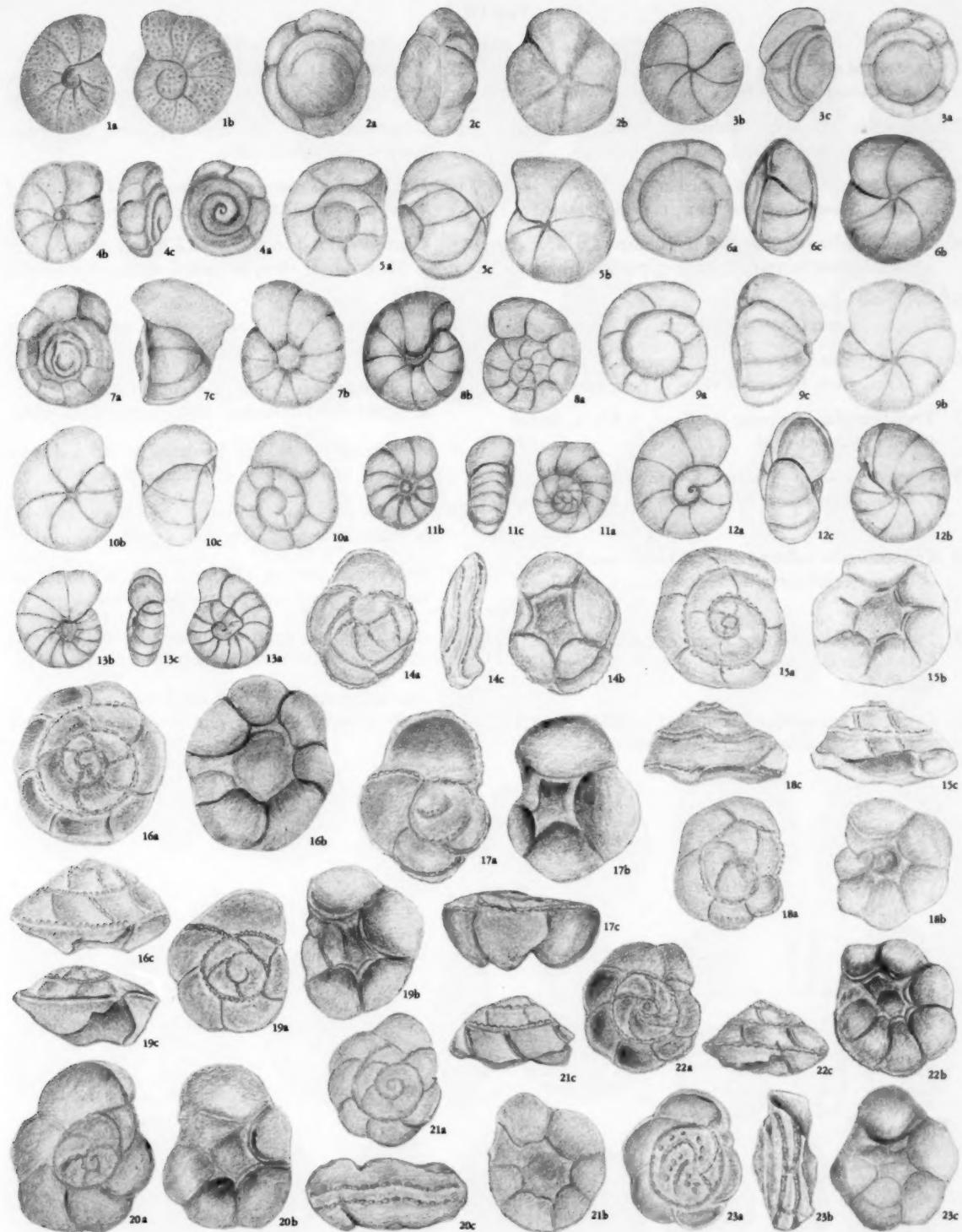
47 *Gavelinella brotzeni* Said and Kenawy, n. sp.,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.



SAID AND KENAWY

PLATE 5

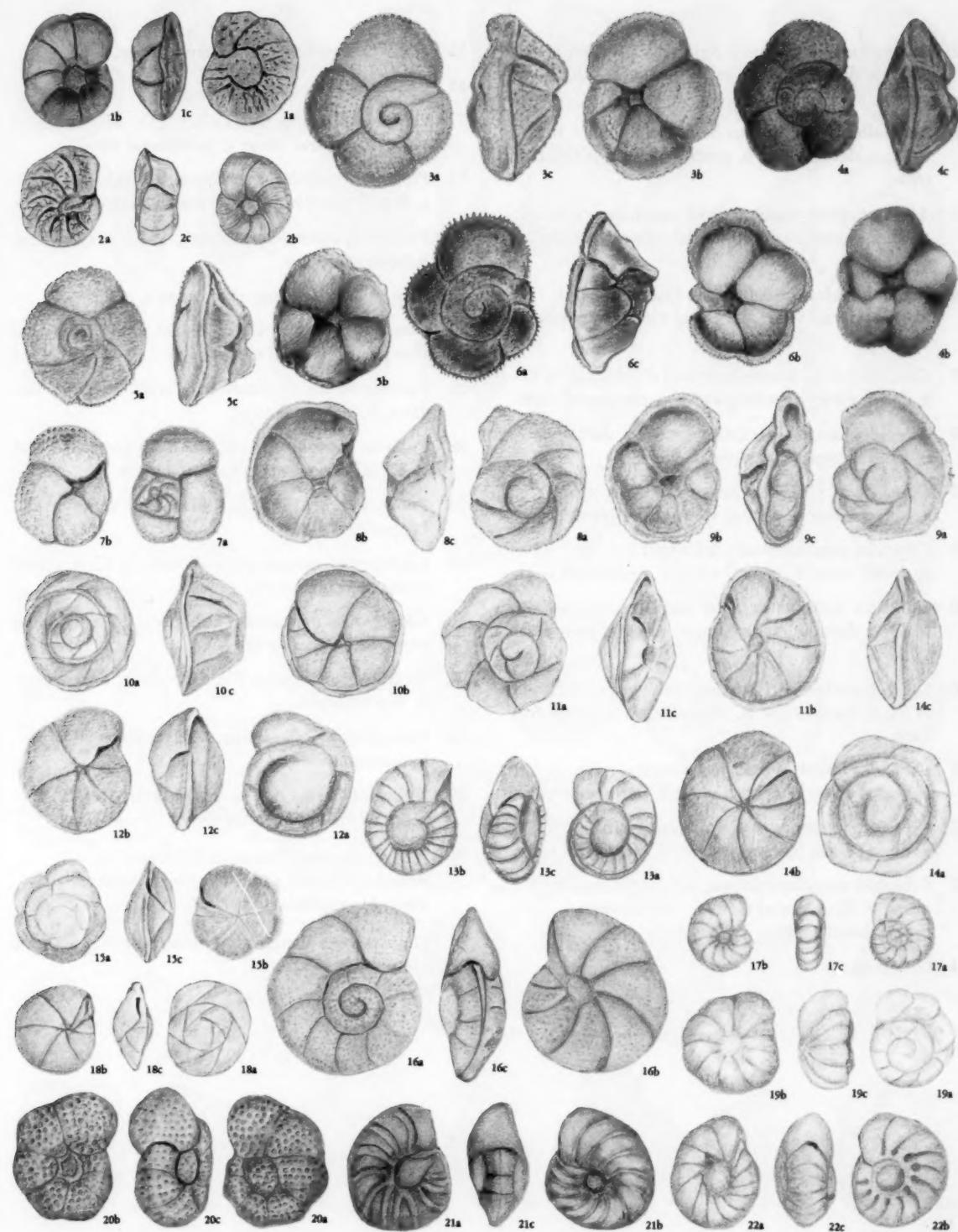
- 1 *Gavelinella* cf. *G. pertusa* (Marsson),  $\times 65$ : a, dorsal view; b, ventral view.
- 2 *Eponides mariei* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 3 *Eponides lunatus* Brotzen,  $\times 32$ : a, dorsal view; b, ventral view.
- 4 *Eponides simplex* (White),  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 5 *Gyroidina globosa* (Hagenow),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 6 *Eponides sigali* Said and Kenawy, n. sp.,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 7 *Gyroidina girardana* (Reuss),  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 8 *Gyroidina planulata* Cushman and Renz,  $\times 65$ : a, dorsal view; b, ventral view.
- 9 *Gyroidina subangulata* (Plummer),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 10 *Gyroidina reussi* Said and Kenawy, n. sp.,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 11 *Gyroidina depressa* (Alth),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 12 *Gyroidinoides nitidus* (Reuss),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 13 *Gyroidinoides frizzelli* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 14 *Globotruncana lapparenti lapparenti* Brotzen,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 15 *Globotruncana intermedia* Bolli,  $\times 47$ : a, dorsal view; b, ventral view; c, edge view.
- 16 *Globotruncana conica* White,  $\times 47$ : a, dorsal view; b, ventral view; c, edge view.
- 17 *Globotruncana gansseri* Bolli,  $\times 65$ : a, dorsal view; b, ventral view; c, edge view.
- 18 *Globotruncana caliciformis* Vogler,  $\times 65$ : a, dorsal view; b, ventral view; c, edge view.
- 19 *Globotruncana aegyptiaca* Nakkady,  $\times 47$ : a, dorsal view; b, ventral view; c, edge view.
- 20 *Globotruncana lapparenti tricarinata* (Quereau),  $\times 65$ : a, dorsal view; b, ventral view; c, edge view.
- 21 *Globotruncana esnehensis* Nakkady,  $\times 47$ : a, dorsal view; b, ventral view; c, edge view.
- 22 *Globotruncana stuarti* (de Lapparent),  $\times 47$ : a, dorsal view; b, ventral view; c, edge view.
- 23 *Globotruncana mayaroensis* Bolli,  $\times 47$ : a, dorsal view; b, edge view; c, ventral view.



SAID AND KENAWY

PLATE 6

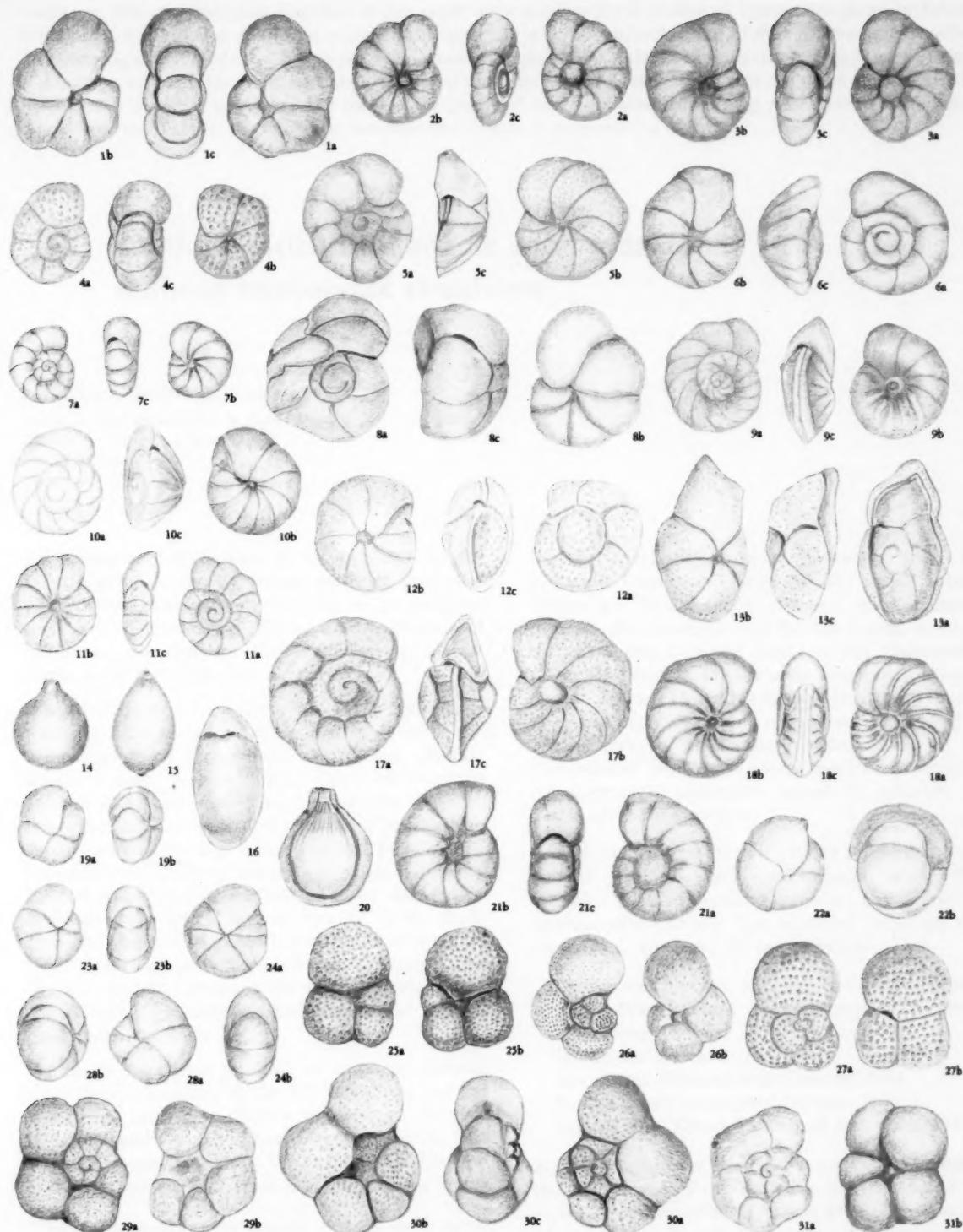
- 1 *Stensiöina americana* Cushman and Dorsey,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 2 *Stensiöina excolata* (Cushman),  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 3 *Truncorotalia spinulosa* (Cushman),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 4 *Truncorotalia velascoensis* (Cushman),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 5 *Truncorotalia colligera* (Schwager),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 6 *Truncorotalia simulatilis* (Schwager),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 7 *Truncorotalia esnaensis* (LeRoy),  $\times 65$ : a, dorsal view; b, ventral view.
- 8 *Truncorotalia crassata aequa* (Cushman and Renz),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 9 *Truncorotalia wilcoxensis* (Cushman and Ponton),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 10 *Pseudoparrella obtusa* (Burrows and Holland),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 11 *Osangularia expansa* (Toulmin),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 12 *Höglundina* cf. *H. scalaris* (Franke),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 13 *Neorotalia* sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 14 *Höglundina esnaensis* (LeRoy),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 15 *Charltonina toddae* Said and Kenawy, n. sp.,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 16 *Anomalina grandis* LeRoy,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 17 *Anomalina umbonifera* (Schwager),  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 18 *Alabamina wilcoxensis* Toulmin,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 19 *Streblus convexus* (LeRoy),  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 20 *Anomalina granosa* (Hantken),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 21 *Anomalina pseudoacuta* Nakkady,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 22 *Anomalina misrensis* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.



SAID AND KENAWY

PLATE 7

- 1 *Anomalinoides nakkadyi* Said and Kenawy, n. sp.,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 2 *Anomalinoides suturatus* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 3 *Anomalinoides stinaensis* Said and Kenawy, n. sp.,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 4 *Anomalinoides vanbelleni* ten Dam and Sigal,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 5 *Cibicides* cf. *C. beaumontianus* (d'Orbigny),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 6 *Cibicides farafrensis* LeRoy,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 7 *Cibicides* cf. *C. abudurbensis* Nakkady,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 8 *Cibicides praecursorius* (Schwager),  $\times 22$ : a, dorsal view; b, ventral view; c, peripheral view.
- 9 *Cibicides nekhlianus* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 10 *Cibicides schwageri* Said and Kenawy, n. sp.,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 11 *Cibicides loeblichii* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 12 *Cibicides tappanae* Said and Kenawy, n. sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 13 *Cibicides megaloperforatus* Said and Kenawy, n. sp.,  $\times 32$ : a, dorsal view; b, ventral view; c, peripheral view.
- 14 *Oolina* sp.,  $\times 65$ .
- 15 *Oolina reussi* Said and Kenawy, n. sp.,  $\times 65$ .
- 16 *Chilostomella czjzeki* Reuss,  $\times 32$ .
- 17 *Cibicidoides libycus* (LeRoy),  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 18 *Planulina multifaria mellahensis* Nakkady,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 19 *Pullenia quaternaria* (Reuss),  $\times 32$ : a, side view; b, apertural view.
- 20 *Fissurina orbignyana* (Seguenza),  $\times 65$ .
- 21 *Nonionella* sp.,  $\times 47$ : a, dorsal view; b, ventral view; c, peripheral view.
- 22 *Pullenia reussi* Cushman and Todd,  $\times 32$ : a, side view; b, apertural view.
- 23 *Pullenia quinqueloba angusta* Cushman and Todd,  $\times 47$ : a, side view; b, apertural view.
- 24 *Pullenia coryelli* White,  $\times 47$ : a, side view; b, apertural view.
- 25 *Globigerina pseudotriloba* White,  $\times 47$ : a, dorsal view; b, ventral view.
- 26 *Globigerina bulloides* d'Orbigny,  $\times 47$ : a, dorsal view; b, ventral view.
- 27 *Globigerina linaperta* Finlay,  $\times 65$ : a, dorsal view; b, ventral view.
- 28 *Pullenia jarvisi* Cushman,  $\times 32$ : a, side view; b, apertural view.
- 29 *Rugoglobigerina esnehensis* Nakkady,  $\times 65$ : a, dorsal view; b, ventral view.
- 30 *Rugoglobigerina "cretacea" Cushman* of Bermudez,  $\times 65$ : a, dorsal view; b, ventral view; c, peripheral view.
- 31 *Globigerina subcretacea* Łomnicki,  $\times 65$ : a, dorsal view; b, ventral view.





**ABSTRACT:** The sporomorphae described in this paper correspond to the definition of *Tasmanites* given by Schopf, Wilson and Bentall. This contribution attempts to promote a better understanding of their nature and to reduce the nonnomenclatorial confusion arising from the Brazilian samples sent to Dawson by Hartt and by Derby. A study of topotype material has convinced the author that the microfossils called *Tasmanites* are not a constellation of reproductive particles or spores, but represent a group of micro-organisms deserving systematic independence. A family of fossil algae, *Tasmanaceae* (incertae sedis), is here proposed for them.

## South American Paleozoic sporomorphae without haptotypic structures

FRIEDRICH WILHELM SOMMER\*

Departamento Nacional da Produção Mineral  
Divisão de Geologia e Mineralogia  
Rio de Janeiro

The purpose of this paper is to contribute to the knowledge of a very interesting group of sporomorphae, which promise to be of help in stratigraphic work. Their presence may offer an additional means of correlation, especially in cores and whenever macrofossils are absent from the samples studied.

Our attention was first called to these sporomorphae when we were studying the problems involved in the nomenclature of *Protosalvinia braziliensis* Dawson emend. Kräusel (Sommer, 1951). This fossil, from the State of Pará, was studied for the first time by J. W. Dawson in 1884. It was found in material from the Rio Trombetas and the Rio Curuá that had been sent to Dawson by O. A. Derby. Several years before studying Derby's material, Dawson had received some other Brazilian plant fossils sent to him by C. F. Hartt. Dawson, who had proposed the name *Sporangites* for North American sporomorphae before his study of the Brazilian material, changed the name to *Protosalvinia* and included the North American species of *Sporangites* under it as well.

We are in a position to check on topotype material from Derby's localities on the Rio Trombetas and the Rio Curuá, and from Hartt's localities on the Rio Tapajós above Itaituba (or, as Dawson wrote it, "Rio Tapagos above Itaituba"). We believe that Dawson found, in the material from the Rio Tapajós above

Itaituba, sporomorphae of the unicentric group belonging to *Tasmanites* (Newton, 1875) emend. Schopf, Wilson and Bentall, 1944, and that, in the material from the Rio Trombetas and the Rio Curuá, he found thalloid bodies (Kräusel, 1941) of the *Algomyctes*, *Foerstiales*, that is, *Protosalvinia braziliensis* Dawson emend. Kräusel. Our study has shown that, up to now, these two microfossils have never been found together in drill cores or in outcrop samples. Moreover, the *Protosalvinia braziliensis* spores, with their conspicuous haptotypic structures, cannot be mistaken for *Tasmanites* sporomorphae.

Schopf, Wilson and Bentall (1944) resolved the systematic problem very satisfactorily when they emended Newton's genus *Tasmanites* and defined its characteristic features. The following forms are now recognized, according to the literature:

*Tasmanites* (Newton, 1875) emend. Schopf, Wilson and Bentall, 1944 (genoholotype: *Tasmanites punctatus* Newton, 1875);  
*Sporangites* Dawson, 1863;  
*Sporangites (Protosalvinia)* Dawson, 1884;  
*Protosalvinia (Sporangites)* Dawson, 1886;  
*Leiosphaera* (Eisenack) Kräusel nov. comb. 1941.

A shale sample from Barreirinha, a locality situated on the Rio Tapajós above Itaituba, is of the same age as the North American Hamilton group, according to Moura (1932). It contained quite a number of sporo-

\* Under the auspices of the Conselho Nacional de Pesquisas, Rio de Janeiro.

## SOMMER

morpae, although they are not nearly so abundant as in a sample of dark shale from the "east side of the Olentangy River about 20 miles north of Columbus in southern Delaware County, Ohio." We are fortunate in having this sample for comparison, through the kindness of Dr. J. M. Schopf.

Because of their practical value in stratigraphy, we studied the Barreirinha sporomorpae from a morphological point of view. Eight species were differentiated on the basis of form, dimensions, color in transmitted light (they have not been chemically treated), discrete to conspicuous punctae, and centripetal "rays" and folds. The following species were described (Sommer, 1953) from the Barreirinha shale:

### **Tasmanites tapajonensis** Sommer Plate 1, figures 1 and 4; plate 2, figure 6

Round sporomorpae from 200 to 500 microns in diameter, averaging about 300 microns; ornamentation consisting exclusively of numerous punctae or pores that are seen to be shallow depressions when observed under higher magnification, distributed uniformly over the entire surface, sometimes more concentrated in the central part of the disc, producing the appearance of an outer ring that is lighter in color; color in transmitted light ranging from light orange to saturated dark orange. Of the 200 specimens sampled, 93 belong to this species.

### **Tasmanites roxoi** Sommer Plate 1, figures 2 and 5; plate 2, figures 1 and 8

Round sporomorpae from 370 to 520 microns in diameter; ornamentation consisting of circles about 8 microns in diameter, which occupy the central part of the disc surface, leaving a marginal ring about 50 microns in width without circles but provided with centripetal rays; the latter, when magnified in transmitted light, are seen to be straight canals filled irregularly with an opaque substance. These canals appear undistorted in the marginal ring, where they are ray-like, but become more and more foreshortened toward the center of the disc. It is possible to follow them through several optical planes, but in the center they

appear as conspicuous black dots in the centers of circles. Under higher magnification, the circles are resolved into cones excavated into the surface, with the apices pointing toward the center and continuing as canals filled with an opaque substance. The color of the disc in transmitted light is a saturated reddish brown, with which the marginal rays, inclined canals, central rings, and dots contrast sharply. Three of the 200 sporomorpae belong to this species.

### **Tasmanites avelinoi** Sommer Plate 1, figures 3 and 6; plate 2, figures 2 and 9

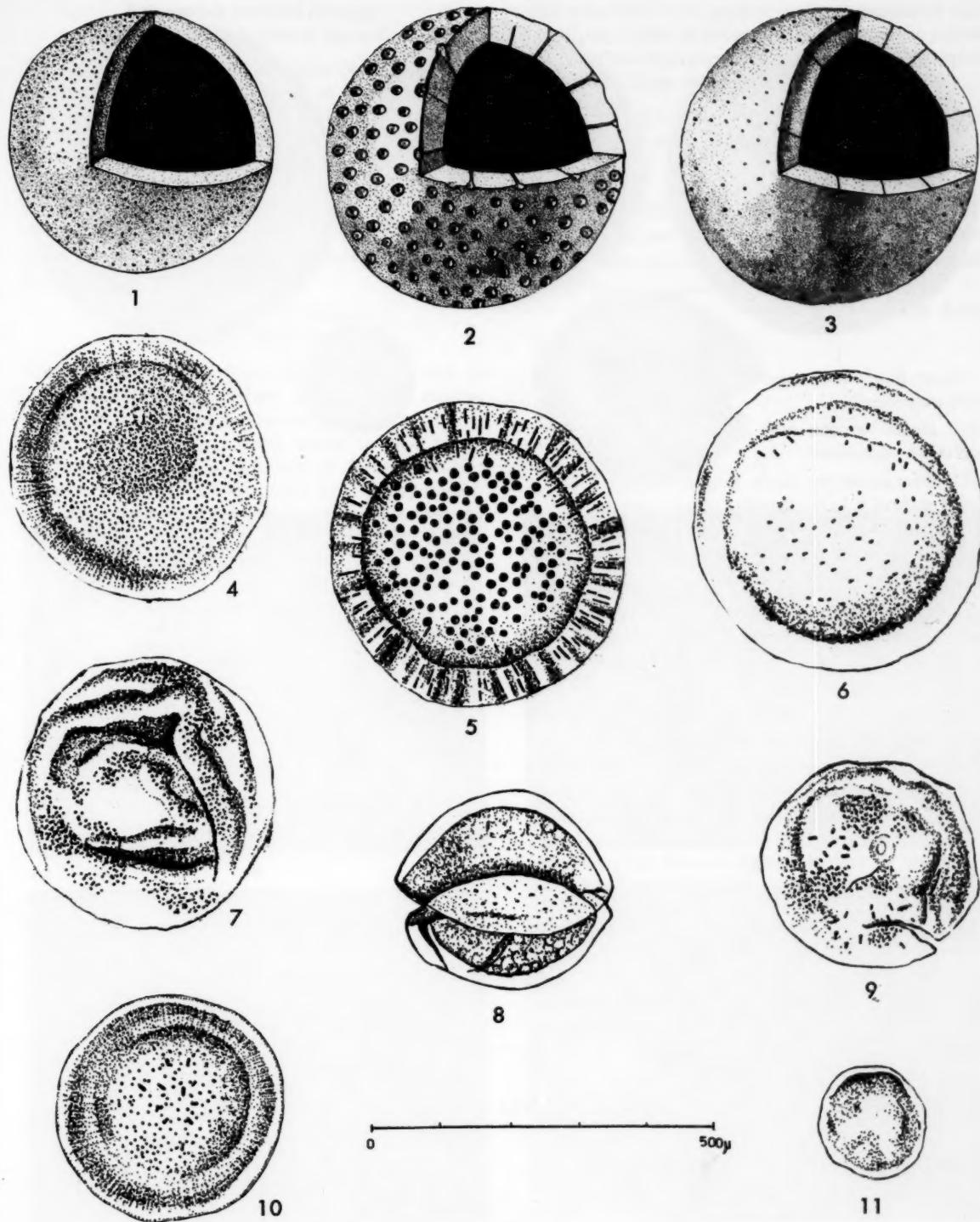
Round sporomorpae from 310 to 710 microns in diameter, with a fairly conspicuous outer ring; ornamentation consisting of narrow needle-like structures, more or less inclined, entering the disc and crossing several optical planes. Under higher magnification, these structures are seen to be canals irregularly filled with opaque material. These canals are evenly distributed and not very numerous. They are narrower than those in *Tasmanites roxoi*. A number of irregularly excavated depressions situated along the inner circle of the outer ring may represent additional ornamentation. The color in transmitted light is orange to reddish-brown. The outer ring devoid of ornamentation, as well as the few details distributed over the rest of the surface, and the rich saturated color, give these sporomorpae the appearance of being well preserved. There were 17 representatives of this species in the 200 specimens examined.

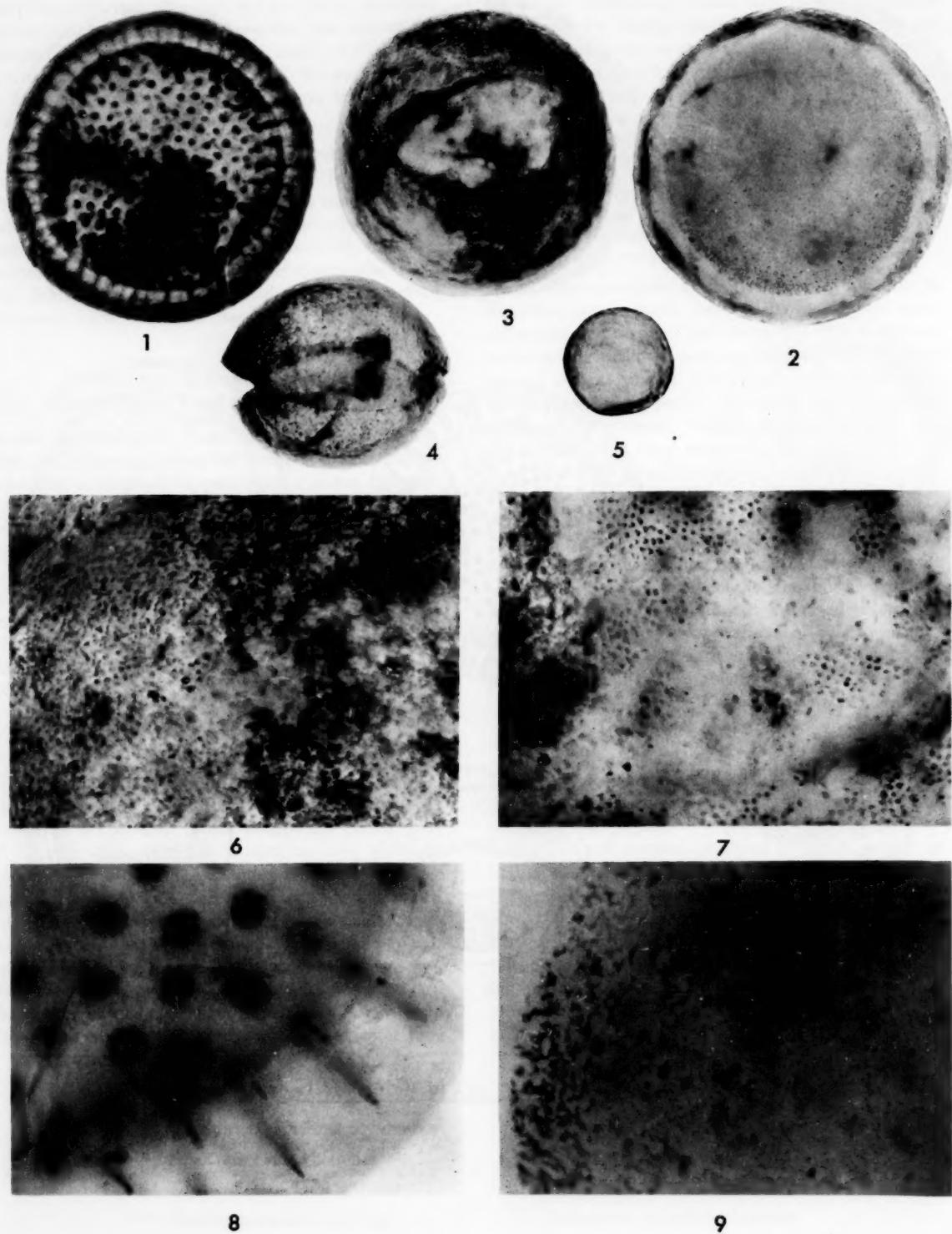
### **Tasmanites mourai** Sommer Plate 1, figure 7; plate 2, figures 3 and 7

Round sporomorpae from 370 to 490 microns in diameter, with an irregular outline and a worn, wrinkled and corroded aspect; ornamentation consisting of well-marked punctae or pores, which at higher magnification present an irregular outline. The pores, generally conspicuously dark, contrast strongly with the surface, which is normally light in color; they are distributed in patches of denser concentration. Folds, darker in color, cross the surface, producing an irregular pattern. Color in transmitted light orange-yellow. Of the 200 specimens examined, 14 belong to this species.

## PLATE 1

1, 4 <i>Tasmanites tapajonensis</i> Sommer	8 <i>Tasmanites euzebii</i> Sommer
2, 5 <i>Tasmanites roxoi</i> Sommer	9 <i>Tasmanites derbyi</i> Sommer
3, 6 <i>Tasmanites avelinoi</i> Sommer	10 <i>Tasmanites hartti</i> Sommer
7 <i>Tasmanites mourai</i> Sommer	11 <i>Tasmanites salustianoi</i> Sommer





## PALEOZOIC SPOROMORPHAE

### **Tasmanites euzebiori Sommer** Plate 1, figure 8; plate 2, figure 4

Oval sporomorphae, major diameter from 370 to 520 microns, some of them appearing as if the fragments of a collapsed sphere, with a shell thickness about 1/10 as great as the diameter, were piled one upon the other. This shell or outer margin very rarely shows the usual perforations, such as dark rays or canals, crossing it. Its color in transmitted light is uniformly orange; the inner part is irregularly brown to reddish brown. Of the 200 specimens examined, 18 belong to this species.

### **Tasmanites derbyi Sommer** Plate 1, figure 9

Round sporomorphae from 370 to 520 microns in diameter, irregular in outline; ornamentation consisting of a number of narrow penetrating canals slanting in various directions, of pores similar to those found in *Tasmanites tapajonensis*, and of folds producing irregular patterns. In transmitted light the sporomorphae are light orange in color, the folds are darker and are reddish brown. Of the 200 specimens examined, six specimens belong to this species.

### **Tasmanites hartti Sommer** Plate 1, figure 10

Round sporomorphae from 325 to 460 microns in diameter; ornamentation consisting of conspicuous pores, which, under higher magnification, appear as shallow excavations distributed principally over the central part of the disc, and of a few slanting canals of irregular distribution, also situated in the central portion. Color in transmitted light saturated orange. This is a sporomorpha of *tapajonensis* aspect with penetrating canals. Of the 200 examined, 14 specimens belong to this species.

### **Tasmanites salustianoi Sommer** Plate 1, figure 11; plate 2, figure 5

Almost circular sporomorphae from 160 to 210 microns in diameter; ornamentation consisting of a few inclined penetrating canals, narrow and not easily visi-

ble; some folds are present, and a conspicuous marginal ring. Color is transmitted light brilliant yellow, the marginal ring more saturated. In the total sampled, there were three representatives of this species.

The following key is intended as an aid in the identification of the eight species from Barreirinha:

#### A. With pores

- a) Pores only ..... *Tasmanites tapajonensis*
- b) Pores and narrow canals ..... *Tasmanites hartti*
- c) Pores and folds ..... *Tasmanites mourai*
- d) Pores, narrow canals, and folds ..... *Tasmanites derbyi*

#### B. Without pores, with ring

- a) Conspicuous ring, circles, and broad canals ..... *Tasmanites roxoi*
- b) Conspicuous ring, few narrow canals, folds ..... *Tasmanites salustianoi*
- c) Conspicuous ring, some specimens with a few narrow canals; appearance of a broken sphere with fragments flattened and superposed ..... *Tasmanites euzebiori*
- d) Conspicuous ring, narrow centripetal canals, regularly spaced ..... *Tasmanites avelinoi*

In addition to this *Tasmanites* constellation, the Barreirinha shale sample yielded, according to Lange (1952), two species of Chitinozoa, *Lagenochitina avelinoi* Lange and *Angochitina mourai* Lange.

A sample from the Devonian Ponta Grossa shales of Jaguariaiva, State of Paraná, yielded the following sporomorphae: *Tasmanites* cf. *roxoi*, *Tasmanites* cf. *avelinoi*, *Tasmanites* cf. *mourai*, and *Tasmanites* cf. *euzebiori*. This constellation consists of four groups of sporomorphae that are similar to four of the species from the Barreirinha shale. It is interesting to note that *Tasmanites tapajonensis*, which predominates in the Barreirinha material, is not found in the Jaguariaiva sample. Another interesting fact is the presence in the Jaguariaiva material, on the sporomorphae, of an invasion of micro-organisms which we consider to be fungi with a yeast-like habit (Sommer, 1955a). These

## PLATE 2

- 1, 8 *Tasmanites roxoi* Sommer
- 2, 9 *Tasmanites avelinoi* Sommer
- 3, 7 *Tasmanites mourai* Sommer
- 4 *Tasmanites euzebiori* Sommer
- 5 *Tasmanites salustianoi* Sommer
- 6 *Tasmanites tapajonensis* Sommer

## SOMMER

organisms have been described under the name of *Paulomyces dolianitii* Sommer. Although a large number of sporomorphae found in the Barreirinha material has been examined, no sign of the above-mentioned invasion has been encountered there. To the best of our present knowledge, it is confined to the Paraná material and to the Bolivian specimens described below.

A Devonian shale from Bolivia (Barbosa, 1949) has also yielded sporomorphae. As in the case of the Barreirinha material and the Jaguariaiva sample, the Bolivian shale did not contain abundant specimens. The sporomorphae found in this shale form a constellation that is similar to that of Jaguariaiva. Among thirty-three specimens, we consider that eleven belong to *Tasmanites* cf. *mourai*. There is one specimen that deserves special mention, because, as far as we know, it is the first Devonian spore of the *Triletes* group recognized in South America. It was described (Sommer, 1955b) as *Triletes boliviensis*.

We are indebted to Dr. Salustiano de Oliveira for a collection of Devonian shale samples from various outcrops in the Tapajós River region. The sporomorphae found in these samples support our concept of these peculiar microfossils.

We have also examined a series of drill cores from the oil exploration carried on in 1925 at Bom Jardim, in the town of Itaituba, State of Pará. The drilling penetrated Carboniferous, Devonian and Silurian beds. We did not find any *Tasmanites* sporomorphae in the Carboniferous material, but they are present in Devonian shales, and we traced them downward to the Silurian, where *Tasmanites* cf. *salustianoi* is present, along with the graptolite *Climacograptus* sp.

In summary, *Tasmanites* sporomorphae represent peculiar microfossils for which we purposely avoid using the term "spores." We hope that further study and new material will help us to understand this group more fully. The absence of haptotypic structures and the peculiar ornamentation are considered significant. The thanatocoenoses in which they are found indicate marine sediments. They have never been found in samples from the Brazilian Carboniferous, contrary to the statement of Schopf, Wilson and Bentall that their range is "Devonian to Mississippian black shale." We believe that we understand Dawson's reasoning because of his acquaintance with Brazilian material, and we hope to offer, in another paper, a morphologic sequence justifying his change of generic name. Even today, there is some confusion between these forms. For example, we have found *Punctati-sporites* illustrated as *Tasmanites* (Francis, 1954, fig. 2.70.1).

From a study of the literature as well as of material at our disposal, we are convinced that the *Tasmanites* microfossils treated here do not represent specialized reproductive particles such as spores or ova, but were independent organisms. The unicentric morphological arrangement, the spherical form flattened into a disc by pressure, and the absence of scars of contact and of haptotypic structures support this view, and might be expected as a consequence of a tetradic position. These features seem to justify assigning these microfossils to the independent systematic position here indicated:

### ALGAE INCERTAE SEDIS

#### Family *Tasmanaceae* Sommer, new family

The following is a diagnosis of the family *Tasmanaceae*: Unicentric organisms, originally spherical, generally compressed to a disc; haptotypic structures absent; ornamentation without high relief, that is, sculpture not extending beyond the outer coat. Genus *Tasmanites* (Newton, 1875) emend. Schopf, Wilson and Bentall, 1944.

#### ACKNOWLEDGMENTS

We wish to express our sincere thanks to Dr. Alberto Ribeiro Lamego, Director of the Divisão de Geologia e Mineralogia, Departamento Nacional da Produção Mineral, Rio de Janeiro, for his continued interest and help in our research, and to the Conselho Nacional de Pesquisas, Rio de Janeiro, for its financial assistance. Our colleague Mario Carnaval made the photomicrographs.

#### BIBLIOGRAPHY

BARBOSA, O.  
1949 - *Vegetais fósseis do Devoniano do Brasil e da Bolívia. Mineração e Metalurgia*, Rio de Janeiro, vol. 14, no. 81, pp. 81-84.

CLARKE, J. M.  
1885 - *On Devonian spores*. Amer. Jour. Sci., ser. 3, vol. 29, pp. 284-289.

DAWSON, J. W.  
1863 - *Synopsis of the flora of the Carboniferous period in Nova Scotia*. Canadian Nat., new ser., vol. 8, no. 6, pp. 431-457.  
1866 - *On the conditions of the deposition of coal, more especially as illustrated by the coal-formation of Nova Scotia and New Brunswick*. Geol. Soc. London, Quart. Jour., vol. 22, pp. 95-169.  
1871a *On spore cases in coals*. Amer. Jour. Sci., ser. 3, vol. 1, no. 4, pp. 256-263.  
1871b *On spore cases in coals*. Canadian Nat., new ser., vol. 5, pp. 369-377.  
1871c *The fossil plants of the Devonian and Upper Silurian formations in Canada*. Canada, Geol. Survey.

## PALEOZOIC SPOROMORPHAE

1884a *On rhizocarps in the Paleozoic period.* Amer. Assoc. Adv. Sci., Proc., 32d meeting (Minneapolis, 1883), pp. 260-264.

1884b *On rhizocarps in the Paleozoic period.* Canadian Rec. Sci., vol. 1, pp. 19-27.

1885 - *Sobre os rhizocarpos do periodo paleozoico (dos schistos dos Rios Trombetas e Curuá).* Rev. Engenharia, Rio de Janeiro, p. 1-t.

1886 - *On rhizocarps in the Erian (Devonian) period in America.* Chicago Acad. Sci., Bull., vol. 1, no. 9, pp. 105-118.

1888a *On sporocarps discovered by Prof. E. Orton in the Erian shale of Columbus, Ohio.* Canadian Rec. Sci., vol. 3, pp. 137-140.

1888b *Geological history of plants.* International Scientific Series, London, vol. 63.

DERBY, O. A.  
1883 - *Plantas fósseis (no Brasil).* Jornal do Commercio do Rio de Janeiro, Rev. Engenharia, p. 348.

DOLIANITI, E.  
1948 - *A paleobotânica no Brasil.* Brazil, Div. Geol. Min., Bol., no. 123.

EISENACK, A.  
1931 - *Neue Mikrofossilien des baltischen Silurs; I. Pal. Zeitschr.*, vol. 13, p. 74.

1938 - *Hystrichosphaerideen und verwandte Formen im baltischen Silur.* Zeitschr. Geschiebef., vol. 14.

1948 - *Mikrofossilien aus Kieselknollen des böhmischen Ordoviziums.* Senckenbergiana, vol. 28, p. 105.

FRANCIS, W.  
1954 - *Coal.* London: Edward Arnold Ltd.

GOTHAN, W., AND WEYLAND, H.  
1954 - *Lehrbuch der Paläobotanik.* Berlin: Akad. Verlag.

KRÄUSEL, R.  
1941 - *Die Sporokarpien Dawsons, eine neue Thallophytenklasse des Devons.* Palaeontographica, vol. 86, pt. B, pp. 113-135.

LANG, W. H.  
1945 - *Pachytheca and some anomalous early plants (Pro-totaxites, Nematothallus, Parka, Foerstia, Orvillea n. g.).* Linnean Soc. London, Jour., Bot., vol. 52, pp. 535-552.

LANGE, F. W.  
1952 - *Chitinozoides do folhelho Barreirinha, Devoniano do Pará.* Dusenia, Curitiba, Paraná, vol. 3, no. 5, pp. 373-386.

MOURA, P. DE  
1932 - *Reconhecimentos geológicos no vale do Tapajós.* Brazil, Serv. Geol. Min., Bol., no. 67.

NEWTON, E. T.  
1875 - *On "tasmanite" and Australian "white coal."* Geol. Mag., dec. 2, vol. 2, no. 8, pp. 337-342.

OLIVEIRA, A. I. DE, AND LEONARDOS, O. H.  
1943 - *Geologia do Brasil.* Rio de Janeiro: Serviço de Informação Agrícola, Ministério da Agricultura.

OLIVEIRA, E. P. DE  
1937 - *Estado atual da paleobotânica brasileira.* Brazil, Serv. Geol. Min., Notas Prelim. e Estudos, no. 10-11; Mineração e Metalurgia, vol. 2, no. 7, pp. 7-17.

REINSCH, P. F.  
1884 - *Micro-Palaeophytologia formationis Carboniferae; Vol. I, continens Trileteas et Stelideas.* Erlangen: Theo Krische.

REISSINGER, A.  
1939 - *Die "Pollenanalyse" ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit.* Palaeontographica, vol. 84, pt. B, pp. 1-20.

SCHOPF, J. M., WILSON, L. R., AND BENTALL, R.  
1944 - *An annotated synopsis of Paleozoic fossil spores and the definition of generic groups.* Illinois, Geol. Survey, Rept. Invest., no. 91.

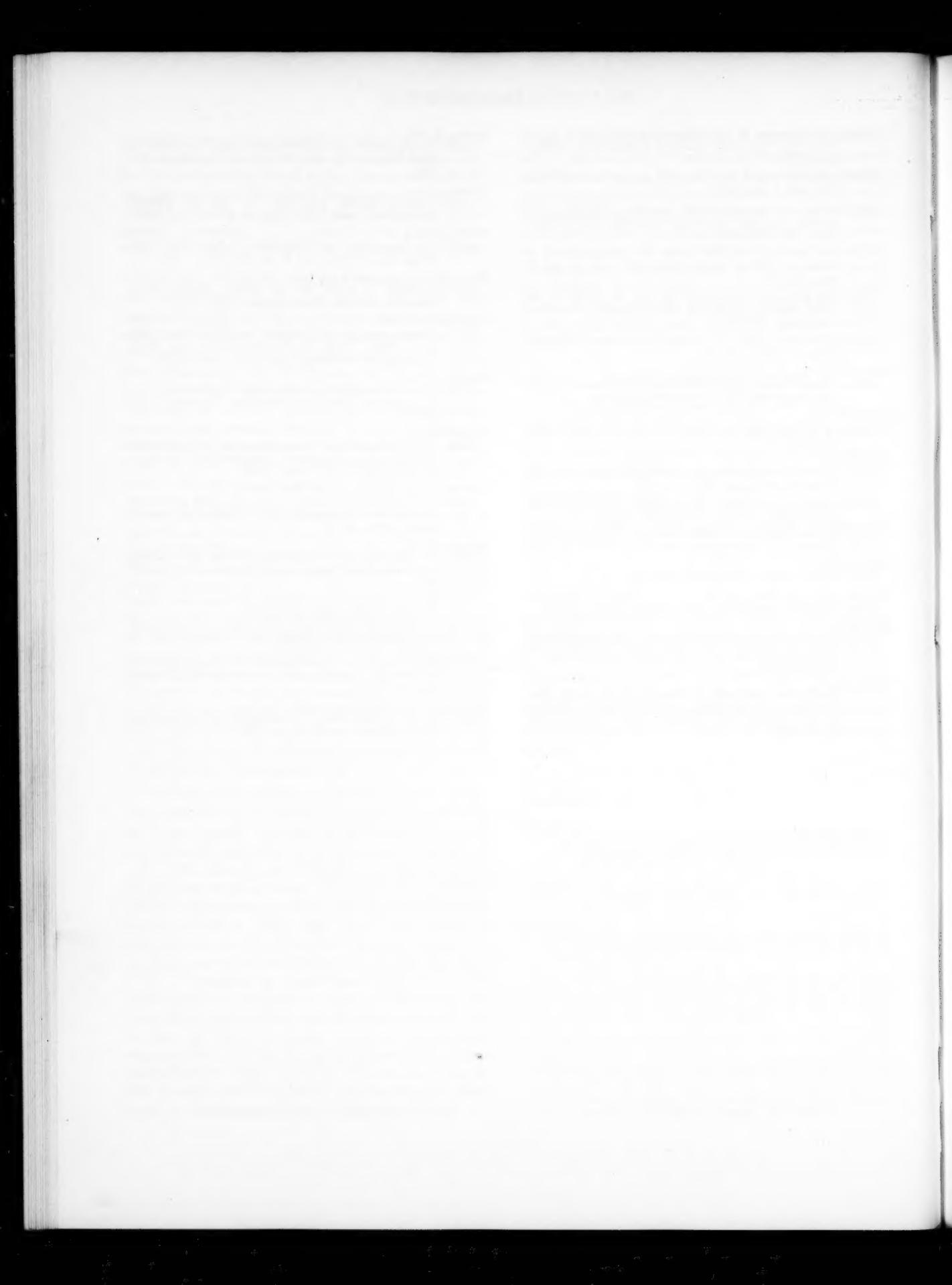
SOMMER, F. W.  
1951 - *O problema de Protosalvinia brasiliensis Dawson.* Acad. Brasileira Cienc., Anais, vol. 23, no. 4, pp. 415-419.

1953 - *Os esporomorfos do folhelho de Barreirinha.* Brazil, Div. Geol. Min., Bol., no. 140.

1955a *Contribuição à paleofotografia do Paraná.* In: *Paleontologia do Paraná.* Curitiba.

1955b *Contribuição ao conhecimento dos esporomorfos do Oriente da Bolívia.* Acad. Brasileira Cienc., Anais, vol. 27, no. 3.

WHITE, D. H., AND STADNICHENKO, T.  
1923 - *Some mother plants of petroleum in the Devonian black shales.* Econ. Geol., vol. 18.



**ABSTRACT:** The successions of Oligo-Miocene zones of planktonic foraminifera are the same on both sides of the Atlantic, but are not synchronous. The same phenomenon has been observed with regard to the *Miogypsina* sequences. In spite of special difficulties in correlation that are inherent in these groups of organisms, it is fairly certain that a large part of the Central American so-called "Oligocene" is synchronous with the European early and middle Miocene.

## Transatlantic correlation of the Oligo-Miocene by means of foraminifera

C. W. DROOGER

Geological Institute  
University of Utrecht, Netherlands

### INTRODUCTION

In recent articles, Eames, Stainforth, Kugler, and Drooger (1953-1955) have pointed out that the sequences of *Miogypsina* species are nearly identical on both sides of the Atlantic, but that they are strikingly different in age. The *Miogypsinidae* are thought to comprise many valuable index fossils because of the one-way trends in their evolution. However, no definite stratigraphic revision can be based on the *Miogypsinidae* alone. Further and independent evidence is needed, for which the planktonic foraminifera are considered favorable because of their wide geographic distribution.

During the past ten years, several micropaleontologists working in Central America have built up a detailed stratigraphic classification of the Oligo-Miocene based on planktonic foraminifera (Cushman, Stainforth, Bronnimann, Bolli, Grimsdale). They have established a sequence of index species that can be recognized rather easily. In Trinidad, some ten successive zones have been distinguished.

Our knowledge of the stratigraphic distribution of these fossils in Europe is very scanty, however, especially with regard to the type sections of the various stratigraphic stages. In order to relate the *Miogypsina* time-scale to that based on planktonic forms, numerous samples from Europe and North Africa have been investigated. Samples from the Trinidad zones were also made available for comparison by Dr. Bolli.

Thanks are extended to all who aided in this work by sending material or by making valuable comments and

suggestions. The group includes D. A. J. Batjes, H. M. Bolli, G. Colom, T. F. Grimsdale, R. Grill, H. Hagn, H. Hiltermann, H. G. Kugler, A. Papp, M. Rey, Maria Ruscelli, R. F. Rutsch, R. M. Stainforth, and Ruth Todd. Our thanks also go to the companies and institutions with which these persons are associated.

### CORRELATION BY PLANKTONIC FORAMINIFERA

The passive transportation of planktonic foraminifera by marine currents is responsible for their wide distribution. Unfortunately, however, correlation by means of these organisms is hampered by a number of unfavorable factors, which fall into two major groups. The first factor is concerned with species limits. The morphology of these organisms is relatively simple, and there is no generally accepted hierarchy of characters. There is also considerable gradual variation both in space and in time. There are no distinct evolutionary trends. As a result, most species consist of a more or less well defined type with a cluster of variants around it, the cluster commonly being interpreted differently by different authors. Many of these species grade into one another, even within a single sample. Individuals from a single sample, which have been separated into more than one species, in reality often belonged to a single biological population. Transgression of generic boundaries is not uncommon in these morphologically intergrading series. The so-called species in such a sample are often types in a series of successive growth stages, but they may also be different adult variants.

## DROOGER

However unsatisfactory this situation may be from a biological point of view, it appears, in the present state of our knowledge, that this narrow, artificial species-concept is the most useful from a stratigraphic point of view. Recognition of a series of variants elevated to specific rank is the best way to deal with the variability of an assemblage of individuals, the morphology of which is often difficult to express in descriptive terms, especially when the evolutionary pattern is intricate and seemingly meaningless. A species may occupy several possibly unconnected positions in populations that are remote from one another both in space and in time. The notorious *Globigerina bulloides*, though often misinterpreted, is an example.

Some of the variants probably represent a response to special environmental conditions. One such variation, which probably occurs because the animal entered an unfavorable environment, deserves special mention. It is the forming of an aberrant final chamber, different in shape and position from all previously formed chambers. Such chambers may occur at different stages of ontogenetic development. Although induced by the environment, in some periods of time these aberrant chambers were often rather uniform. As a result, such species as *Globigerina dissimilis*, *Globigerinatella insueta*, and *Globigerinita naparimaensis* became good index fossils.

The second group of difficulties encountered in correlation is related to the facies limitations of the organisms. Although they are transported passively, their life environment is restricted to the open sea by salinity, food, and temperature factors. The degree of influence exerted by these factors is not generally understood. From their distribution in Recent seas, it is known that different species are differently adapted to the temperatures of the water; associations in colder waters consist of fewer species and, for the most part, of forms not found in the Tropics. As a consequence, these organisms are not generally found in great quantities in sediments deposited beneath water masses that were unfavorable to their existence.

A related factor is the size-range of individuals, which depends, among other things, upon depositional processes such as sorting. A restricted size-range may have been caused by cutting out smaller or larger specimens from the series, and may thus give an erroneous impression of the fauna.

Extreme care should be taken in drawing conclusions from negative evidence in fossil associations. The type sequences of the Oligo-Miocene stages in Europe were, in many cases, formed under conditions unfavorable to

the existence of planktonic foraminifera. Some (for example, the Tongrian) are fluvial or brackish-water deposits, and, as a consequence, devoid of marine planktonic fossils. Many of the type sections represent shallow-water marine deposits, selected because of their wealth of benthonic fossils, especially mollusks. The type sections of the Chattian, Aquitanian, Burdigalian and Helvetian are examples of this kind. They contain only a few planktonic foraminifera or none at all. Furthermore, some sections are situated so far north that climatic factors may be much more important there than they are in connection with faunas from Central America.

The widely different habitats of the Miogypsinidae (shallow, near shore) and the planktonic foraminifera (open ocean) present further difficulties in correlating the two groups. Once the relationships between them have been established, however, they should, together, cover a wide field of correlation possibilities.

### EUROPEAN FAUNAS

The material available from Oligocene type deposits was rather disappointing. Numerous samples from the Rupelian (Middle Oligocene) of Belgium (pl. 1, fig. 5) and some samples from the equivalent "Septarienton" of Hermsdorf and Pietzpuhl, Germany (pl. 1, figs. 6-7), yielded a monotonous fauna of small *Globigerines* ranging up to 300 $\mu$  in size. Most of the specimens resemble *Globigerina bulloides*, but they are often somewhat flattened dorsally and have an oblique aperture in the final chamber, the apertures of the earlier chambers not being visible in the umbilicus. Among the smaller variants, four-and-one-half- and five-chambered individuals occur occasionally; they differ from *Globigerina ciperoensis* in the flatter dorsal side and in the chambers increasing more rapidly in size. Larger variants often have three to three and one-half chambers in the final coil, while the ultimate chamber is rather inflated ventrally and is provided with a wide, oblique aperture.

The same types, especially the larger forms ranging up to 500 $\mu$ , were found in the Oligocene (Stampian) of Biarritz, at Chambre d'Amour and Phare Saint-Martin (pl. 1, figs. 1-4). These larger variants in our Oligocene deposits are characterized by the low to flat dorsal spire, the high later chambers, and the oblique aperture. Although their identity could not be established, they will be referred to tentatively as *Globigerina globularis* Roemer. (Our *Globigerina globularis* is believed to be identical with the form illustrated as "*Globigerina triloculinoides*(?) Beck (not Plummer)"

## OLIGO-MIOCENE CORRELATION

by Stainforth (1948b, pl. 25, figs. 32-33) from the Oligocene of coastal Ecuador. Roemer's figures are very poor, but they suggest the same type. So far, we have failed to find this type at Osnabrück and Kassel, the original localities of *Globigerina globularis*. The associations at hand are similar to those from most European Oligocene localities, but the maximum size of the individuals is very small, about 325 $\mu$ . This may be why the typical three-chambered forms are absent.) This variant was also encountered in the Upper Eocene of Biarritz.

An aberrant final chamber was found now and then in specimens of all sizes. It often covers the umbilicus, as it does in *Globigerina dissimilis*; in other individuals it is situated lower, against the final convolution. These Oligocene assemblages most closely resemble that of the *Globigerina* cf. *apertura* zone (Bronnimann, 1950; Suter, 1951), which is the lowermost zone in the Trinidad succession.

Samples from Escorneboué and Saint Étienne-d'Orthe, in southwestern France, with numerous *Miogypsina complanata* and *Lepidocyclina tournoueri* and occasional *Lepidocyclina raulini*, contain small numbers of Globigerines (pl. 1, fig. 9). *Globigerina globularis* is dominant among the larger specimens, which range up to 550 $\mu$ . Among the smaller variants, specimens of *Globigerina ciperoensis* measuring up to 275 $\mu$  were frequently found. Umbilical chambers were also observed. Some small individuals are similar to *Globigerina mayeri*; a few others have an additional dorsal aperture. The fauna of these deposits is probably closest to that of the *Globigerina ciperoensis* zone of Trinidad. Its Upper Oligocene age is indicated by the presence of the pre-Aquitanian species *Miogypsina complanata*, but it cannot be correlated directly with the Chattian, because our material from the type deposits of that stage in Germany contained no Globigerinidae other than a poorly developed *Globigerina globularis* assemblage (pl. 1, fig. 8).

At another locality, Puente Viejo in Spain, *Miogypsina complanata* sensu lato was found in association with Globigerines (pl. 1, figs. 11-13). The planktonic fauna of this locality is very distinctive. It consists of numerous specimens of *Globigerina dissimilis*, together with *Globigerina mayeri*, *Globigerina globularis*, *Globigerina venezuelana*, and a very few specimens of *Globigerina concinna*. This assemblage seems to be related to the *Globigerina dissimilis* zone of Trinidad. As to its age, however, it is probable that the deposits are early Miocene (Aquitanian), and that the *Miogypsina* are reworked.

The planktonic microfauna of the type deposits of the Aquitanian and Burdigalian is very poor, although not dwarfed. It is a rather neutral fauna, composed of *Globigerinoides triloba*, *Globigerina bulloides*, and *Globigerina globularis* (pl. 1, figs. 17-18). This situation affords no opportunity for direct correlation of the planktonic zones with the *Miogypsina gunteri-intermedia* sequence of these stages.

However, a nearly identical *Miogypsina* series, *Miogypsina tani-mediterranea*, was found in Morocco, with intercalated beds containing numerous well developed Globigerines, although in a rather poor state of preservation. With minor variations, this fauna invariably contains *Globigerinoides triloba*, *Globigerina mayeri*, *Globigerina venezuelana*, *Globigerina dissimilis*, *Globocyclina* sp., and some specimens of *Globigerina bulloides* and *Globigerina globularis* (pl. 1, figs. 14-16). This is clearly the *Globigerina dissimilis* zone of Trinidad. Because it has been suggested (Drooger, 1954c) that the Burdigalian-Vindobonian boundary in the western Mediterranean region coincides with the boundary between *Miogypsina intermedia* and *Miogypsina cushmani*, the *Globigerina dissimilis* zone would seem to range into the Middle Miocene. This conclusion is the more certain because the next younger *Globigerinatella insueta* zone was found higher in the Moroccan section of Si-Ameur in a sample from the "marnes de la cuvette" (pl. 1, figs. 21-26), well above the occurrence of the final *Miogypsina* species, *Miogypsina mediterranea*. The sample contains numerous *Globigerinoides bisphericus*, in addition to *Globigerinoides triloba*, *Globigerina mayeri*, *Globigerinatella naparimaensis*, *Globocyclina*, and small *Globorotalia fohsi*. (*Globigerinoides bisphericus* is an index fossil of the *Globigerinatella insueta* zone (Todd, Cloud, Low and Schmidt, 1954). It replaces *Globigerinatella insueta* at several localities outside Trinidad. In our material, indistinct specimens of *Globigerinatella insueta* were found occasionally, but *Globigerinoides bisphericus* is always present.)

Evidently, then, the beginning of the *Globigerinatella insueta* zone lies above the last occurrence of *Miogypsina* in the Mediterranean region. Observations in Spain and Italy support this conclusion.

The transgressive Miocene beds of Majorca contain distinct *Miogypsina mediterranea*. *Globigerina* marls somewhat higher in the sequence contain mainly *Globigerina mayeri*, *Globocyclina* sp., *Globigerina dissimilis*, and *Globigerinoides triloba*, with occasional specimens similar to *Globigerinoides bisphericus* among the smaller individuals (pl. 1, fig. 19). This assemblage represents the *Globigerina dissimilis* zone rather than

## DROOGER

the *Globigerinatella insueta* zone. A much younger assemblage, with *Globigerinoides triloba*, *Globigerinoides sacculifer*, *Sphaeroidinella multiloba*, *Orbulina*, and *Globigerinella aequilateralis*, was encountered in a sample from a higher part of the Majorcan Miocene (pl. 1, figs. 38-42).

In northern Italy, the youngest Miogypsinae belong to the later Burdigalian species *Miogypsina intermedia*. Much higher in the same sequence, at Superga-Baldissoro, a sample was found that contained numerous specimens of *Globigerinoides bisphericus* and *Globigerinoides triloba*, and some other unidentifiable Globigerines (pl. 1, fig. 20). Still higher, two samples were found that contained a rich fauna of *Globigerinoides triloba*, *Globigerinoides bisphericus*, *Orbulina suturalis*, and *Globoquadrina* (pl. 1, figs. 27-29). This assemblage appears to correspond to the lower part of the *Globorotalia fohsi* zone. Unfortunately, Globigerines were encountered only rarely in association with the northern Italian Lower Miocene species of *Miogypsina* sensu stricto. Some forms similar to *Globigerina dissimilis* were recognized.

The typical Helvetician in Switzerland is disappointing from a micropaleontological point of view. No planktonic foraminifera were found in our samples.

The microfauna of the typical Tortonian of Tortona, Italy, was recently described by Gianotti (1953). The planktonic association is characterized throughout by the presence of *Orbulina* and *Globorotalia* (pl. 1, fig. 37). The species association indicates the upper part of the *Globorotalia fohsi* zone, or younger. However, an almost identical fauna was found by Ruscelli in the beds directly below the Tortonian; these beds were referred to as Helvetician. The Oligocene of Tortona, according to di Napoli (1953), carries a different fauna, containing *Globigerina dissimilis*, *Globigerina venezuelana*, and *Globigerinoides triloba*. In our opinion, this association indicates an early Miocene rather than an Oligocene age.

The Vindobonian of the Vienna Basin consists of a lower and an upper part, which correspond more or less, in facies and in relative age, with the typical Helvetician and Tortonian, respectively. The available samples give no clear picture of the succession of planktonic associations. *Orbulina* (commonly represented by *Orbulina suturalis*) is evidently restricted to the upper Vindobonian (Grill, written communication). Other common forms are *Globigerina bulloides* and *Globigerinoides triloba*. *Globigerina mayeri*, *Globigerina concinna*, *Globoquadrina* sp., and *Globorotalia fohsi* were encountered less frequently (pl. 1, figs.

30-36). In one sample, forms similar to *Globigerinoides bisphericus* were observed. One or two specimens of *Globorotalia menardii* were encountered by Marks (1951). Although the situation is confused, the evidence, as a whole, points to the *Globorotalia fohsi* zone.

The few samples from the lower Vindobonian contain an unusual fauna, possibly of provincial character. It is dominated by *Globigerina concinna*. In a sample from the lowermost Vindobonian, this species seems to grade into *Globigerina ciperoensis*, and forms similar to *Globigerina globularis* are present. (Size is the main distinguishing feature between *Globigerina concinna* and *Globigerina ciperoensis* (Bolli, 1954). The latter species usually has a distinctly elevated dorsal spire, whereas most of the specimens of *Globigerina concinna* from the type region, the Vienna Basin, are more flattened dorsally and the chambers increase somewhat more rapidly in size. In our opinion, *Globigerina ciperoensis* is a young form of the *Globigerina globularis* series, whereas *Globigerina concinna*, especially specimens from the upper Vindobonian, is a five-chambered variant of the *Globigerina bulloides* group.)

### TRANSATLANTIC CORRELATION

Summarizing our scattered data, we find that we do have some positive data, such as the occurrences of *Globigerinoides bisphericus*, *Orbulina*, and the younger species of *Globorotalia*. On the other hand, not much can be concluded, as yet, from the distribution of such forms as *Globigerina bulloides* and *Globigerina concinna* because of their vague species limits in several morphological series.

In Europe, the *Globorotalia fohsi* and younger zones evidently occupy the upper part of the Vindobonian. The *Globigerinatella insueta* zone is also well up in the Middle Miocene. The *Globigerina dissimilis* zone probably extends from a horizon in either the Aquitanian or the uppermost Oligocene, through the Burdigalian, and into the lower part of the Vindobonian. The *Globigerina ciperoensis* zone is difficult to identify in Europe; it may be represented in the uppermost Oligocene. Climatic factors may have been responsible for its lack of distinctness. The same factors must be borne in mind with regard to the statement that almost the entire Oligocene corresponds to the lowermost zone in Trinidad, the zone of *Globigerina cf. apertura* or *Globigerina globularis*.

If the planktonic foraminifera, with their wide dispersal, are given great importance in transatlantic correlation, and if there are no serious shortcomings in

## OLIGO-MIOCENE CORRELATION

our conclusions, the Central American zones of *Globorotalia foehsi* and *Globigerinatella insueta*, and at least the major part of the zone of *Globigerina dissimilis*, must be placed in the Miocene. This means that in the older systems of Caribbean foraminiferal stratigraphy (not the classification recently developed by Bolli and by Kugler (1954), in which the *Globorotalia foehsi* zone is transferred to the Miocene), the Middle and Upper Oligocene correspond approximately to the lower Middle Miocene of the classic European time-scale.

In general, this shift corresponds to the discrepancies between the *Miogypsina* successions on the two sides of the Atlantic. *Miogypsina gunteri* and *Miogypsina tani*, which occur in the Aquitanian of Europe, have been reported mainly from the Middle Oligocene deposits of the older Caribbean stratigraphic system. The *Miogypsina* sequence of species has often been considered to end near the Oligo-Miocene boundary in America, whereas the corresponding European end-member is Middle Miocene.

Unfortunately, there is, as yet, very little information on the correlation between the *Miogypsina* sequences and the successions of zones of planktonic foraminifera in America. Kugler has remarked that Trinidad is not a good locality for this purpose, since *Miogypsina*s have been found only in slip masses on that island. Stainforth reports (written communication) that in Peru the horizon of *Miogypsina gunteri* and *Miogypsina ecuadorensis* probably lies within the *Globigerina dissimilis* zone. Akers has reported *Globigerinatella insueta*, *Orbulina*, and *Globorotalia* from deposits much younger than those containing the *Miogypsina*s of the Gulf Coast. Many of the Central American occurrences of *Miogypsina* are in tectonically unstable areas, so that it may prove difficult and time-consuming to establish a reliable correlation. Many of the larger foraminifera are likely to be present in secondary deposits such as slip masses or displaced unconsolidated sediments, as they are in Morocco and at Puente Viejo in Spain.

Consideration of the evidence furnished by a well known evolutionary series, on the one hand, and by planktonic index foraminifera on the other, indicates, in our opinion, that earlier transatlantic correlations were largely incorrect. Kugler (1953) has already presented macrofossil evidence that supports this conclusion.

### THE EUROPEAN TIME-SCALE

A further step must be taken to connect the boundaries of the European stages with the two foraminiferal

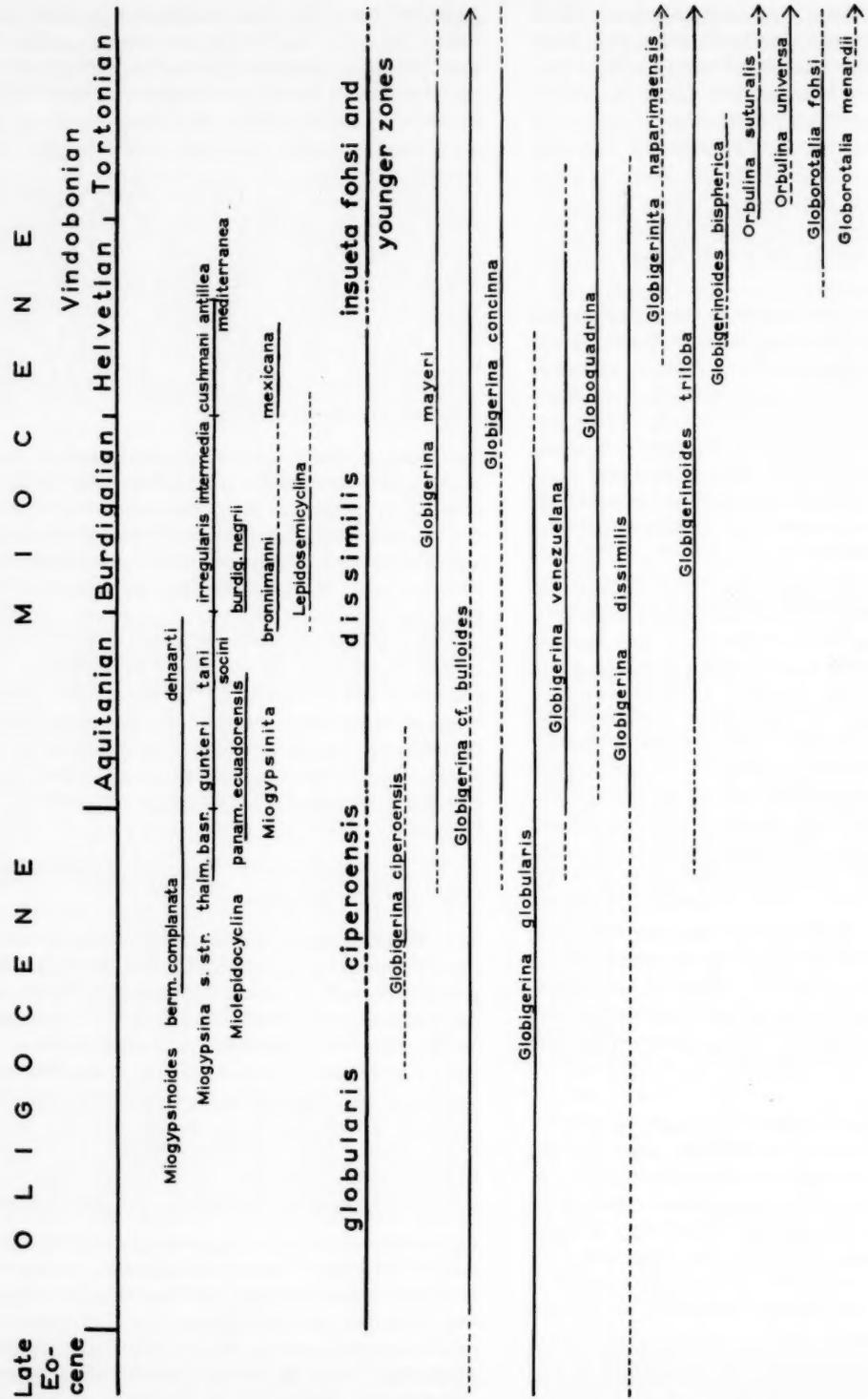
scales. These scales offer at least as good, if not a better, means of world-wide correlation as the other fossils, such as mollusks, previously used for this purpose. It will, no doubt, be possible for future workers to add evidence from still other fossil groups as they are studied in detail, which may further support these revised correlations. The Lepidocyclus, for example, may prove to be very helpful in this respect. The range of the genus itself, or those of its subgenera, probably cannot be used, however. The extinction of *Lepidocyclus* differs with respect to that of *Miogypsina* between Europe and America and between those areas and the western Pacific. However, the final species in each of these regions are probably markedly different. Consequently, a thorough knowledge of the sequence of species is needed.

The *Miogypsina* time-scale apparently permits a greater refinement than does the *Globigerina* scale in its corresponding range. The *Miogypsina* scale is continuous; it is very unlikely that there are gaps anywhere in it. Differences of age between corresponding units in different parts of the world must be considered possible, but there is, as yet, no evidence that such differences are of marked extent. Whether or not the Oligo-Miocene scale based on planktonic foraminifera is continuous is not yet certain. The boundaries between the successive zones are probably less sharp than in the *Miogypsina* scale because of our difficulties with species limits, but the boundaries are theoretically less susceptible to age variations in different parts of the world.

At present, the succession is tentatively believed to be as follows (see text-figure 1):

The Oligocene is, for the most part, characterized by the *Globigerina globularis* association, with the *Globigerina ciperoensis* association occurring in its final portion. Early species of *Miogypsina* are another guide to the latest Oligocene, and some primitive species of *Miogypsina* sensu stricto, such as *Miogypsina thalmanni* and *Miogypsina basraensis*, may also be of that age. There are, as yet, no foraminiferal associations defining the Lattorfian-Rupelian or Rupelian-Chattian boundaries. The end of the Chattian is considered to be fixed by the beginning of the Aquitanian.

Aquitanian species are *Miogypsina gunteri*, *Miogypsina tani*, *Miogypsina socini*, *Miogypsina panamensis*, *Miogypsina ecuadorensis*, and the younger species of the subgenus *Miogypsina*. The *Globigerina dissimilis* association starts close to the beginning of the Aquitanian (early Miocene), possibly slightly earlier or somewhat later.



## TEXT-FIGURE 1

Tentative correlation chart of the Miogypsinas and some of the Oligo-Miocene planktonic foraminifera. The distribution of the planktonic species is based on European and North African data only. The horizontal subdivisions are not proportional to the actual time-intervals.

## OLIGO-MIOCENE CORRELATION

The Burdigalian begins with the life-range of *Miogypsina irregularis*; other *Miogypsina* species of this stage are *Miogypsina intermedia*, *Miogypsina burdigalensis*, *Miogypsina negrii*, and at least some of the species of the subgenus *Lepidosemicyclina*. The end of the Burdigalian may be fixed at the change from *Miogypsina intermedia* to *Miogypsina cushmani*.

The Vindobonian seems to have been relatively long in comparison with the early Miocene stages. It is recommended that this stage be subdivided into the Helvetic and Tortonian stages. The type deposits of these two stages are not only different in facies, but also very probably successive in time. Unfortunately, from our point of view, the typical Helvetic is indefinite. With our present methods and data, the limits of the Helvetic must be defined by those of the adjoining stages. Its beginning is identifiable in the *Miogypsina* scale by the appearance of *Miogypsina cushmani*. *Miogypsina* ranges through the earlier part of the Helvetic, with *Miogypsina antillea* and *Miogypsina mediterranea* the latest species. The range of *Miogypsina* ends approximately at the horizon where the *Globigerina dissimilis* association is replaced by that of *Globigerinatella insueta*. The end limit of the Helvetic is again indefinite. We suggest that this stage closes with the disappearance of the *Globigerinatella insueta* association and the appearance of *Orbulina*, that is, the *Globorotalia fohsi* association.

If this assumption is true, the Tortonian begins with the appearance of *Orbulina*. The type Tortonian actually lies entirely within the range of *Orbulina*, as the genus is also present in the beds underlying the type Tortonian section (Ruscelli, 1953; Gianotti, 1953). Our delimitation of the Tortonian can be considered correct, however, as long as the Tortonian, thus defined, does not exclude any part of its type deposits nor incorporate part of those of the Helvetic. According to our present data, our definition meets these conditions. This definition of the Tortonian has the advantage of relating a world-wide time-indicator, the *Orbulina* horizon, to our European stratigraphic scale.

No reasonable suggestion can yet be given for fixing the end of the Tortonian or of the Miocene, nor can the Trinidad zones younger than that of *Globorotalia fohsi* be fitted into our classic stratigraphic system.

### BIBLIOGRAPHY

AKERS, W. H.

1955 - Some planktonic foraminifera of the American Gulf Coast and suggested correlations with the Caribbean Tertiary. Jour. Pal., vol. 29, no. 4, pp. 647-664, pl. 65, text-figs. 1-3.

BOLLI, H.

1950 - The direction of coiling in the evolution of some Globorotalidae. Cushman Found. Foram. Res., Contr., vol. 1, pt. 3-4, pp. 82-89, pl. 15, text-figs. 1-5, tables 1-2.

1951 - Notes on the direction of coiling of rotalid foraminifera. Ibid., vol. 2, pt. 4, pp. 139-143, text-fig. 1.

1954 - Note on *Globigerina concinna* Reuss 1850. Ibid., vol. 5, pt. 1, pp. 1-3, text-figs. 1-8.

BRONNIMANN, P.

1950 - Occurrence and ontogeny of *Globigerinatella insueta* Cushman and Stainforth from the Oligocene of Trinidad, B.W.I. Ibid., vol. 1, pt. 3-4, pp. 80-82, pls. 13-14.

1951a *Globigerinatella naparimaensis* n. gen., n. sp., from the Miocene of Trinidad, B.W.I. Ibid., vol. 2, pt. 1, pp. 16-18, text-figs. 1-14.

1951b The genus *Orbulina* d'Orbigny in the Oligo-Miocene of Trinidad, B.W.I. Ibid., vol. 2, pt. 4, pp. 131-138, text-figs. 1-5.

1952 - Micropaleontologic literature 1941-1951 on Trinidad, Tobago and Barbados, B.W.I. Micropaleontologist, vol. 6, no. 1, pp. 23-42.

CUSHMAN, J. A., AND RENZ, H. H.

1947 - The foraminiferal fauna of the Oligocene, Ste. Croix formation, of Trinidad, B.W.I. Cushman Lab. Foram. Res., Spec. Publ. no. 22, pp. 1-46, pls. 1-8.

CUSHMAN, J. A., AND STAINFORTH, R. M.

1945 - The foraminifera of the Cipero marl formation of Trinidad, B.W.I. Ibid., Spec. Publ. no. 14, pp. 3-75, pls. 1-16.

DAVID, L., AND FLANDRIN, J.

1955 - Sur la présence du Miocène à Miogypsines dans les monts de la Haute Medjerda. Soc. Géol. France, Bull., ser. 6, vol. 4 (1954), fasc. 4-6, pp. 415-419, pl. 15, text-figs. 1-2.

DROOGER, C. W.

1951 - Notes on some representatives of *Miogypsinella*. K. Nederl. Akad. Wetensch., Proc., ser. B, vol. 54, no. 4, pp. 357-365, 1 pl., text-figs. 1-3.

1952 - Study of American *Miogypsinidae*. (Utrecht, Univ., doct. diss.) Zeist, Netherlands: the author, pp. 1-80, pls. 1-18, tables 1-3.

1954a *Miogypsina* in northern Italy; I-II. K. Nederl. Akad. Wetensch., Proc., ser. B, vol. 57, no. 2, pp. 228-249, pls. 1-2, text-figs. 1-5, table 1.

1954b *Miogypsina* in northwestern Morocco. Ibid., ser. B, vol. 57, no. 5, pp. 580-591, text-fig. 1.

1954c The Oligocene-Miocene boundary on both sides of the Atlantic. Geol. Mag., vol. 91, pp. 514-518, text-fig. 1.

DROOGER, C. W., KAASSCHIETER, J. P. H., AND KEY, A. J.

1955 - The microfauna of the Aquitanian-Burdigalian of southwestern France. K. Nederl. Akad. Wetensch., Afd. Natuurk., Verh., ser. 1, vol. 21, pp. 1-136, pls. 1-20, text-figs. 1-11, tables.

EAMES, F. E.

1953 - The Miocene/Oligocene boundary and the use of the term Aquitanian. Geol. Mag., vol. 90, pp. 388-392, tables.

1954 - The Caribbean "Oligocene." Ibid., vol. 91, pp. 326-327.

GIANOTTI, A.

1953 - Microfauna della serie tortoniana del Rio Mazzapiedi-Castellania (Tortona-Alessandria). In: Studi stratigrafici e micropaleontologici sull'Appennino tortonese. Riv. Ital. Pal. Strat., Mem. no. 6, pp. 187-301, pls. 10-19, 3 tables.

GRIMSDALE, T. F.

1951 - Correlation, age-determination, and the Tertiary pelagic foraminifera. World Petr. Congr., 3rd, Proc., sect. 1, pp. 463-472, 1 text-fig.

## DROOGER

KUGLER, H. G.

1953 - *Jurassic to Recent sedimentary environments in Trinidad*. Assoc. Suisse Géol. Ing. Pétr., Bull., vol. 20, pp. 27-60, 2 text-figs.

1954 - *The Miocene/Oligocene boundary in the Caribbean region*. Geol. Mag., vol. 91, pp. 410-413.

LEROY, L. W.

1948 - *The foraminifer *Orbulina universa* d'Orbigny, a suggested Middle Tertiary time indicator*. Jour. Pal., vol. 22, pp. 500-508, text-figs. 1-4.

MARKS, P.

1951 - *A revision of the smaller foraminifera from the Miocene of the Vienna Basin*. Cushman Found. Foram. Res., Contr., vol. 2, pt. 2, pp. 33-73, pls. 5-8.

NAPOLI ALLIATA, E. DI

1952 - *Foraminiferi pelagici e facies in Italia (dal Cretacico ad oggi)*. Conv. Naz. Met. Petrol., 7th, sess. 1, pp. 1-35, pls. 1-2.

1953 - *Microfaune della parte superiore della serie oligocenica del Monte San Vito e del Rio Mazzapiedi-Castellania (Tortona-Alessandria)*. In: *Studi stratigrafici e micropaleontologici sull'Appennino tortonese*. Riv. Ital. Pal. Strat., Mem. no. 6, pp. 25-98, pls. 1-4, tables 1-2.

RUSCELLI, M.

1953 - *Microfaune della serie elveziana del Rio Mazzapiedi-Castellania (Tortona-Alessandria)*. In: *Studi stratigrafici e micropaleontologici sull'Appennino tortonese*. Riv. Ital. Pal. Strat., Mem. no. 6, pp. 99-166, pls. 5-9, text-figs. 1-6, 1 table.

STAINFORTH, R. M.

1948a *Description, correlation, and paleoecology of the Tertiary Cipero marl formation, Trinidad, B.W.I.* Amer. Assoc. Petr. Geol., Bull., vol. 32, no. 1, pp. 1292-1330, text-figs. 1-2.

1948b *Applied micropaleontology in coastal Ecuador*. Jour. Pal., vol. 22, pp. 113-151, pls. 24-26, text-figs. 1-2.

1953 - *The basis of Paleogene correlation of Middle America*. Soc. Geol. Peru, Bol., vol. 26, pp. 247-261, text-figs. 1-3.

1954 - *Comments on the Caribbean Oligocene*. Geol. Mag., vol. 91, p. 175.

SUTER, H. H.

1951 - *The general and economic geology of Trinidad, B.W.I.; Part 1. Great Britain, Colonial Geol. Survey, Colonial Geol. and Min. Res., vol. 2, no. 3, pp. 177-217, 17 tables, 4 maps, text-figs., photo*.

TODD, R.

1954 - *The smaller foraminifera in correlation and paleoecology*. Science, vol. 119, no. 3092, p. 448.

TODD, R., CLOUD, P. E., JR., LOW, D., AND SCHMIDT, R. G.

1954 - *Probable occurrence of Oligocene on Saipan*. Amer. Jour. Sci., vol. 254, no. 11, pp. 673-679, text-figs. 1-2.

## PLATE 1

Oligocene and Miocene planktonic foraminifera from Europe and North Africa. All figures  $\times 25$ ; a, ventral view; b, dorsal view; c, peripheral view.

1-2 *Globigerina globularis* Roemer  
Oligocene (Stampian); loc. BZ34, Phare Saint-Martin, Biarritz, France.

3 *Globigerina* cf. *bulloides* d'Orbigny  
Same locality.

4 *Globigerina* cf. *increbescens* Bandy  
Same locality.

5 *Globigerina* cf. *increbescens* Bandy  
Rupelian, type deposits; Batjes' loc. MA651, Boom, Belgium.

6 *Globigerina* cf. *bulloides* d'Orbigny  
Rupelian; loc. 10447 (Hiltermann), Pietzpuhl, Germany.

7 *Globigerina globularis* Roemer  
Same locality.

8 *Globigerina globularis* Roemer  
Upper Oligocene (Chattian); Belm, Astrup, near Osnabrück, Germany (coll. Hiltermann).

9 *Globigerina ciperoensis* Bolli  
Upper Oligocene, beds with *Miogypsina complanata*; loc. A70, Escornebœu, France.

10-12 *Globigerina dissimilis* Cushman and Bermudez  
Aquitian(?), beds with derived *Miogypsinae*; loc. 409A, Puente Viejo, Spain.

13 *Globigerina venezuelana* Hedberg  
Same locality.

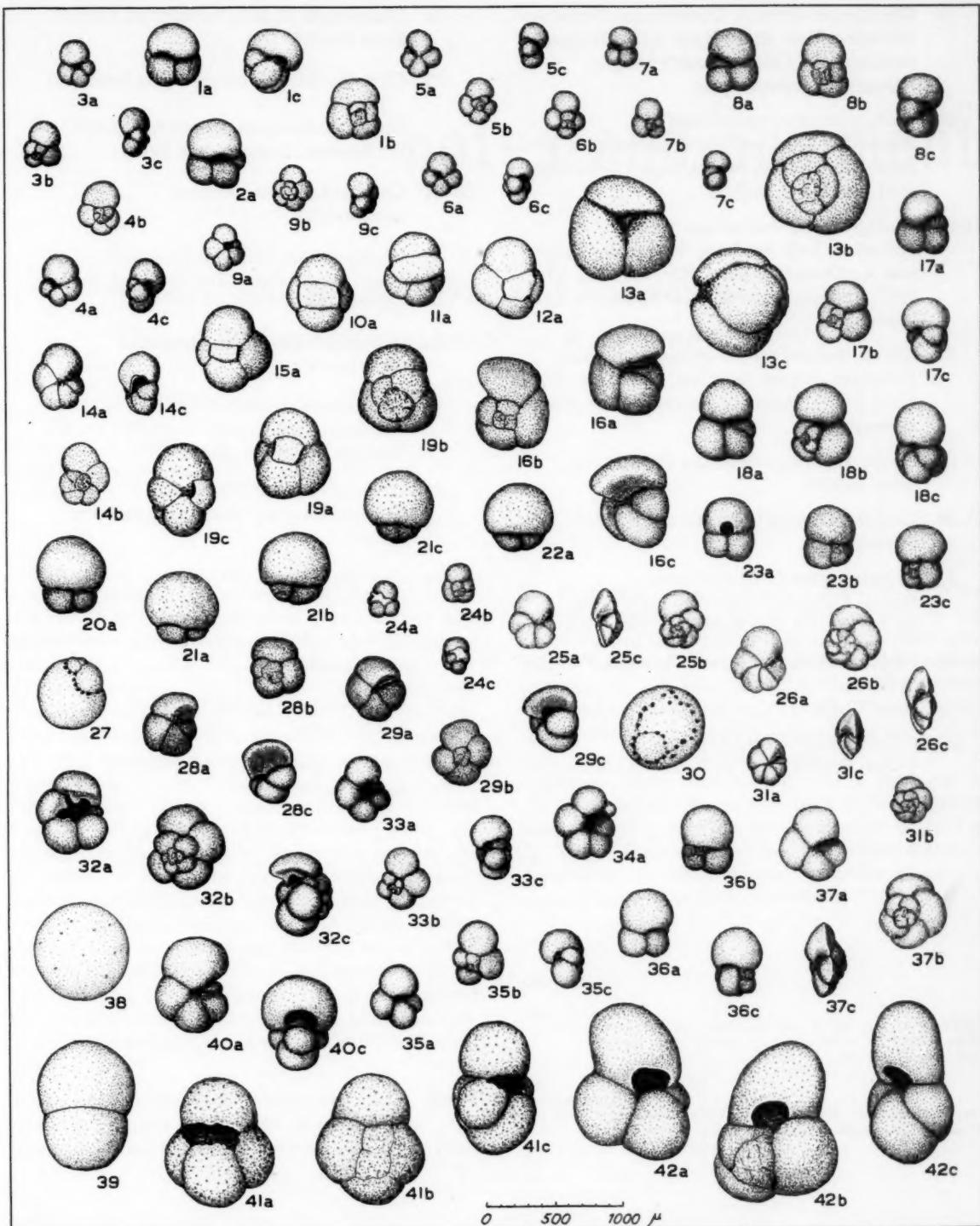
14 *Globigerina mayeri* (Cushman and Ellisor)  
Burdigalian, beds with *Miogypsina irregularis* and *Miogypsina burdigalensis*; Senn's loc. 240A, Djebel Si-Ameur, Morocco.

15 *Globigerina dissimilis* Cushman and Bermudez  
Same locality.

16 *Globoquadrina dehiscens* (Chapman, Parr and Collins)  
Lower Miocene; Senn's loc. 96A, Djebel Rihaïene, Morocco.

17 *Globigerina globularis* Roemer  
Upper Burdigalian (type deposits), beds with *Miogypsina intermedia*; loc. 21, Pont-Pourquery, Bordelais, France.

18 *Globigerinoides triloba* (Reuss)  
Same locality.



**DROOGER**

19 *Globigerina dissimilis* Cushman and Bermudez  
Helvetian, beds above those with *Miogypsina mediterranea*; Colom's locality Malpas (Alcudia), Majorca, Spain.

20 *Globigerinoides bisphericus* Todd  
Helvetian, beds well above those with *Miogypsina intermedia*; loc. 69, Superga-Baldissero road, near Turin, Italy.

21-22 *Globigerinoides bisphericus* Todd  
Helvetian, beds overlying those with *Miogypsina mediterranea*; loc. L912 (coll. Soc. Chér. Pétr., Petitjean), cuvette de Si-Ameur, Morocco.

23 *Globigerinoides subquadratus* Bronnimann  
Helvetian, higher than loc. L912; loc. L911 (coll. S.C.P., Petitjean), cuvette de Si-Ameur, Morocco.

24 *Globigerinoides naparimaensis* Bronnimann  
Same locality.

25-26 *Globorotalia foehsi* Cushman and Ellisor  
Same locality.

27 *Orbulina suturalis* Bronnimann  
Middle Miocene, higher than loc. 69 (see fig. 20); loc. 70, Baldisero, near Turin, Italy.

28-29 *Globoquadrina dehiscens* (Chapman, Parr and Collins)  
Same locality.

30 *Orbulina suturalis* Bronnimann  
Upper Vindobonian; Pelzgasse, Austria (don. Grill).

31 *Globorotalia cf. foehsi barisanensis* LeRoy  
Same locality.

32 *Globoquadrina cf. altispira* (Cushman and Jarvis)  
Upper Vindobonian; Ziegelgrube Karal 1, Walbersdorf, Austria (don. Grill).

33-34 *Globigerina concinna* Reuss  
Same locality.

35 *Globigerina cf. bulloides* d'Orbigny  
Upper Vindobonian; Ziegelei Sooss, Austria (don. Papp).

36 *Globigerinoides triloba* (Reuss)  
Same locality.

37 *Globorotalia canariensis* (d'Orbigny)  
Tortonian, type deposits; Gianotti's loc. 45, Tortona, Italy (don. Ruscelli).

38 *Orbulina universa* d'Orbigny  
Younger Miocene; Majorca, Spain (don. Colom).

39 *Orbulina bilobata* (d'Orbigny)  
Same locality.

40 *Globigerinella aequilateralis involuta* Cushman  
Same locality.

41 *Sphaeroidinella multiloba* LeRoy  
Same locality.

42 *Globigerinoides sacculifer* (Brady)  
Same locality.

# notes and comment

## "*Nodosinella* Brady, 1876, and associated Upper Palaeozoic genera"—A comment

JAMES E. CONKIN

Union Producing Company  
Beeville, Texas

I wish to correct a misinterpretation by Dr. Cummings (1955) of my definition of *Hyperammina* and *Hyperamminoides* (Conkin, 1954). Dr. Cummings stated (1955, pp. 233-234): "It [the relationship between *Hyperammina* and *Hyperamminoides*] has been discussed recently by Conkin (1954), who regards *Hyperamminoides* as a synonym for *Hyperammina*, and who considers the diagnostic features cited for *Hyperamminoides* by Cushman and Waters (1928b), the constricted aperture, siliceous test, and tapering form, as well as that noted by Plummer (1945), the rapidly expanding nature of the second chamber, to be indications of specific variation within *Hyperammina*. Examination of the type material of *Hyperammina* in the British Museum (Natural History) shows that this form has a calcareous or ferruginous-calcereous cement, whereas the wall of *Hyperamminoides* is stated to have siliceous cement. Such a fundamental difference of secretory activity in the cytoplasm cannot be regarded as mere specific variation, as Conkin would suggest."

I agree to all the above statements except that I would not suggest that cement secreted by the cytoplasm of a foraminifer is of mere specific value. Until

Dr. Cummings' announcement, I knew of no reference to *Hyperammina* possessing calcareous or ferruginous-calcereous cement secreted by the cytoplasm; indeed, the generic definition of both *Hyperammina* and *Hyperamminoides* had clearly required that these two genera possess siliceous cement. Therefore, the specific variation to which I referred was not a variation between siliceous cement and calcareous or ferruginous-calcereous cement, but was a variation in the proportion of siliceous cement to cemented grains. This concept is stated in my paper many times, e.g. (p. 168), "Plummer also noted that tests of *Hyperammina* are generally rougher (containing less siliceous cement) than *Hyperamminoides*."

### BIBLIOGRAPHY

CONKIN, J. E.

1954—*Hyperammina kentuckiensis* n. sp. from the Mississippian of Kentucky, and discussion of *Hyperammina* and *Hyperamminoides*. Cushman Found. Foram. Res., Contr., vol. 5, pt. 4, pp. 165-169, pl. 31.

CUMMINGS, R. H.

1955—*Nodosinella* Brady, 1876, and associated Upper Palaeozoic genera. Micropaleontology, vol. 1, no. 3, pp. 221-238, pl. 1, text-figs. 1-10.

## BRAZIL



FREDERICO W. LANGE

Applied micropaleontological work in this country has shown a marked increase during the past year, and several specialists in different fields are now engaged in projects related principally to stratigraphic correlation.

**Divisão de Geologia e Mineralogia, D.N.P.M.**  
Friedrich W. Sommer has been investigating the vertical distribution of Silurian and Devonian plant spores, trying especially to ascertain the range of the various species of *Tasmanites* found in cores from wells drilled in northern Brazil. A paper on the subject has already been submitted for publication in *Micropaleontology*.

Ivan de Medeiros Tinoco has published a preliminary note on foraminifera from the Gramame formation (Cretaceous) of Itamaracá Island, Pernambuco (1955, Brazil, Div. Geol. Min., Notas Prelim. e Estudos, no. 91, pp. 1-12, pls. 1-3). He found the foraminiferal fauna very similar to that of the Upper Cretaceous Navarro group of Texas. At present he is studying Tertiary and Cretaceous as well as Recent foraminifera from the State of Pernambuco.

### Petróleo Brasileiro S. A. (Petrobrás)

Since October, 1955, Dr. Edward J. Zeller and Dr. Doris E. Nodine Zeller have been in charge of the paleontological laboratory of Petrobrás in Belém, Pará. They now have four assistants working with them. The laboratory has the necessary equipment, and will handle paleontological work in the Amazon and Maranhão Basins, as well as in other areas to be developed in northern Brazil. A very abundant fusulinid and endothyroid fauna from one of the wells has already been studied and will be a great help in future correlations with surface samples and with cores from other wells currently being drilled in the area.

Your correspondent is in charge of the Ponta Grossa laboratory of Petrobrás, which is responsible for all paleontologic and subsurface work in southern Brazil. Several assistants are being trained at the laboratory, which has been equipped to handle all work related to petroleum geology. So far, no foraminifera have been found in the Paraná Basin, and micropaleontologic research here has therefore been directed principally toward the evaluation of the stratigraphic value of Paleozoic scolecodonts, *Hystrichosphaeridae* and *Chitinozoa*.

### Universidade de São Paulo, Faculdade de Filosofia, Ciências e Letras

Setembrino Petri has completed a paper on Miocene foraminifera from the Pirabas formation, which deals with both the systematics and the ecology of the assemblage studied. He is presently engaged in the study of Cretaceous foraminifera from Sergipe, northern Brazil.

### Universidade de Rio Grande do Sul, Instituto de Ciências Naturais

Irajá Damiani Pinto is studying fossil ostracodes from several states of Brazil and, in association with Yvonne T. Sanguinetti, has completed work on the morphology, distribution and ecology of Recent ostracodes from Rio Grande do Sul. He is now visiting the United States, where he will spend about six months at the U. S. National Museum, the American Museum of Natural History, and the University of Michigan as well as other institutions. This trip should enable him to meet many of our American colleagues and to study their collections and methods.

### FREDERICO W. LANGE

*Laboratório de Paleontologia Petrobrás  
Ponta Grossa, Paraná, Brazil*

## GERMANY



H. HILTERMANN

The international field meeting sponsored by the Northwest German micropaleontologists is considered to have been the most important event of the past year in the field of micropaleontology. It was a great honor and pleasure to note that such a large number

## news reports

of foreign micropaleontologists had accepted our invitation to visit type localities in northwestern Germany. The aim of our excursion was to serve as an expression of thanks for the kind invitation issued by the Institut Français du Pétrole, Paris. From the 4th to the 9th of September, 1955, about forty micropaleontologists working in universities, in industry, and in government institutions participated in our field meeting. Among other members of the group, we had the honor of welcoming our European colleagues V. Comato, F. Dalbiez, J. G. Durand, W. Klaus, M. Lys, M. Reichel, W. Schors, J. Sigal, and J. H. van Voorhuysen, as well as such distinguished citizens of countries overseas as P. Arni, M. Chatton, M. F. Glaessner, Ch. Glintboeckel, and J. Magné. The excursion took place following the meeting of the Paläontologische Gesellschaft in Clausthal-Zellerfeld. The region covered included the areas of Hannover, Lüneburg, Stade, Wilhelmshaven, Osnabrück, and Bentheim. Only those localities were selected that had furnished microfossils abundantly and in good condition, with special attention being given to the classic localities of the older scientists, in particular those of Count Georg von Münster (1776-1844), Georg August Goldfuss (1782-1848), Friedrich Adolf Roemer (1809-1869), August Emmanuel Ritter von Reuss (1811-1873), Ernst Lienenklaus (1849-1905), and Adolf Franke (1860-1942). Before visiting these localities, each member received a detailed typewritten guide with sections and tables and with an introduction including portraits of, and biographical notes on, the aforementioned classical scientists. A short note by H. Bartenstein and F. Bettenstaedt

referring to this excursion was published in *Erdöl und Kohle* (vol. 8, p. 757).

The most important function of our micropaleontological research has been in connection with stratigraphic problems. This is shown by the papers read at various meetings, and by the micropaleontological papers published during the past year. The Paläontologische Gesellschaft held their annual meeting at Clausthal-Zellerfeld from August 29 to September 3, 1955. H. Bartenstein has already reported briefly upon this meeting in *Erdöl und Kohle* (vol. 8, p. 757). The favorable location of Clausthal-Zellerfeld in the Harz Mountains made it possible for many scientists from the Eastern Zone of Germany to participate, and we are very glad to note that, besides having re-established scientific contact, we were also given an opportunity to make a several days' field trip to the Geiseltal and to Halle/Saale, both of which are in eastern Germany.

Almost sixty papers were read, representing the following four branches of paleontology: Paleobotany, paleozoology, biostratigraphy of the Upper Cretaceous, and applied paleontology. In all of these fields, the topics of discussion included some which dealt in particular with micropaleontological subjects. Besides papers concerning pollen analyses of the Tertiary, others were presented which dealt with the brown coals of Central Europe (by U. Rein and H. D. Pflug) and of Anatolia (von der Brelie), as well as with data obtained from the palynology of older formations, including the Paleozoic salt deposits (G. Leschik) and the Posidonian shale (K. Mädler). In addition, general problems in the phy-

logeny of the foraminifera were outlined by F. Bettenstaedt and A. Papp. Special attention was also drawn to the pelagic foraminifera, particularly *Globotruncana* (H. C. G. Knipscheer for Europe, K. Küpper for America). With regard to the biostratigraphy of the Upper Cretaceous, Hiltermann and Koch spoke on benthonic foraminifera, especially *Bolivinoides* and *Neoflabellina*. By means of their phylogeny, the problems involved in the detailed stratigraphy of a Santonian ore deposit were solved, using the same methods as are usually applied in world-wide stratigraphy. In addition, G. Lüttich presented a paper relating the success which he had had in working out Pleistocene stratigraphy with the help of limnetic ostracodes. F. Goerlich spoke on the microstratigraphy of Yemen and the Red Sea, and H. Beckmann spoke on Paleozoic microstratigraphy.

Two of the so-called "Austauschsitungen für Mikropaläontologie und Stratigraphie" (meetings for the exchange of results in micropaleontology and stratigraphy) were also held during the past year. They were as follows:

**Meeting 78:** On June 23-24, 1955, the Wintershall A.G. Geologisches Büro Bruchsal was host to a meeting for the discussion of the stratigraphy of the Oligocene of the Rheintal-Graben. The following subjects were discussed: By F. Goerlich, the ostracodes of the Aquitanian and upper Chattian; by F. Doebel, the microfaunistic possibilities for a new subdivision of the Aquitanian and upper Chattian between Darmstadt and Karlsruhe; by A. Schad, the stratigraphy and distribution of the Oligo-

cene in the Rheintal-Graben; and by W. Weiler, research on Aquitanian fishes found in the Rheintal-Graben. The meeting closed with a field trip to the well-exposed Middle Oligocene of the clay pits at Wiesloch, near Bruchsal.

**Meeting 79:** Held on August 4, 1955, at the Preussag in Hannover. H. Hiltermann spoke on the recent results of his research on the Eocene of Heiligenhafen in Schleswig-Holstein.

At the meeting of the Deutsche Geologische Gesellschaft held at Krefeld in the spring of 1955, Clara Ellermann spoke on the microstratigraphy of a pit section comprising the Tertiary of the Nieder-Rhein area. H. Fiebig and Hilde Grebe presented a paper on the microfauna of the Ruhr Carboniferous. R. Potonié, H. Reichelt, and E. F. Vangerow also dealt with the microflora and microfauna. At a monthly meeting held at Hamburg on November 15, 1955, E. Voigt spoke on the determination of the depth of deposition of marine sediments by means of the epizoa living on Phaeophyceae.

HEINRICH HILTERMANN  
Amt für Bodenforschung  
Hannover, Germany

#### INDIA



S. R. N. RAO

**Assam Oil Company Ltd.**  
**Palaeontological Laboratory, Digboi, Assam**  
Examination of the Eocene rocks exposed along the foothills of the Garo,

Khasi, Jaintia and Mikir Hills has progressed considerably. This study has revealed that rocks of Lower Eocene, Palaeocene and Upper Cretaceous age are confined to the central part (Khasi and Jaintia Hills) of this region. Middle Eocene foraminifera have been recorded from the lowermost fossiliferous rocks in the Garo and Mikir Hills.

Shales from the Cretaceous sections at Therriaghata (Khasi Hills) have yielded *Globotruncana* cf. *linneiana*, *Globotruncana* cf. *stuarti*, *Gümbelina striata*, *Pseudotextularia* sp., and *Ventilabrella* sp. On the evidence of molluscs and echinoids, Spengler assigned these beds to the Upper Cretaceous in 1923. The presence of the above-mentioned foraminifera further confirms this view.

Investigation in the basal Kopilis has revealed the presence therein of *Hantkenina alabamensis* Cushman. This species has previously been recorded, by Biswas in 1954, from other sections in the Khasi Hills.

Y. Nagappa, palaeontologist with the Assam Oil Company, has recently returned from a study tour of the U.S.A. and Europe. He wishes to convey his gratitude to the numerous fellow-workers whose cooperation and assistance contributed largely to the success of his tour. Dr. Brooks F. Ellis, Chairman of the Department of Micro-paleontology at the American Museum of Natural History in New York, was especially helpful in arranging a comprehensive program for him.

**Birbal Sahni Institute of Palaeobotany,  
Lucknow, Department of Coal, Oil and  
Palaeozoic Palaeobotany**

Investigations of the microflora of Indian Lower Gondwana coals are being continued by Prem Singh, K. M. Lele and G. K. B. Navale under the supervision of D. C. Bhardwaj. D. C. Bhardwaj and B. S. Venkatachala are engaged in a study of Sporae dispersae of the Lower Rotliegend coals near Mainze, western Germany. Bhardwaj and Haripal Singh are engaged in the investigation of Liassic coal from Austria. C. P. Varma is working on the plant microfossils of a Devonian coal

from Norway. Bhardwaj has submitted a paper entitled "The Sporae dispersae of the Upper Carboniferous succession in the Saar and their value in stratigraphical and palaeogeographical studies," for publication in *The Palaeobotanist* (vol. 4). He has another paper, "Plant-Microfossil evidence of the age of the Krol Himalayan boulder beds and associated rocks," ready for publication. S. C. D. Sah has a paper in press on "Plant microfossils from a Jurassic shale of the Salt Range, West Punjab, Pakistan." K. R. Surange and K. M. Lele have found leaf impressions and spores (two-winged as well as one-winged) from Talchir needle shales of the Sukni River section in the Giridih coalfield, Bihar. The Talchir needle shales have hitherto been regarded as unfossiliferous.

**Birbal Sahni Institute of Palaeobotany,  
Lucknow, Department of Geochronology,  
Palynology and Tertiary Palaeobotany**

Vishnu Mittre is working on microfossils *incertae sedis* from the Jurassic Nipania cherts of the Rajmahal Hills. He is also working on spores and pollen from the Miocene deposits of Kasauli, Punjab. Several kinds of pollen grains, including monoporate, polyporate, tricolporate and polycolporate types, have been discovered. Mittre has three papers either published or in press. A paper on "Petrified spores and pollen grains from the Jurassic of the Rajmahal Hills, Bihar" appeared in *The Palaeobotanist* (vol. 3, pp. 117-127). Jurassic spores and pollen grains have recently been discovered in the Nipania chert. Fifty types of the spores are described. Pteridophytic spores, cycadophytic pollen grains, and the winged grains of the conifers are more or less equally represented. The paper also describes some megaspores, which are here reported for the first time from Indian Jurassics.

Mitre's second paper, entitled "*Mastostrobus Sahni*, sp. nov.: A petrified conifer male cone producing three-winged and one- and four-winged abnormal pollen grains from the Jurassic of the Rajmahal Hills, Bihar," was published in *Grana Palynologica* (new ser., vol. 1, no. 2). Under the name

*Masculostrobus Sahnii*, a new Jurassic male cone producing three-winged and one- and four-winged abnormal pollen grains is described. The single wing in the one-winged grains encircles the body of the grain equatorially, like a girdle. The cone has been shown to be podocarpinean in affinities.

The third paper by Mittra, "Sporojuglandoidites jurassicus, nova sporomorpha, from the Jurassic of the Rajmahal Hills, Bihar," is now in press (The Palaeobotanist, vol. 4). A fossil spore showing juglandoid characters is here described for the first time from the Jurassic of India. The sporomorph is distinguished by having foraminoid apertures on its body, which are not known on the spores of fossil and living pteridophytes and gymnosperms. Such apertures are met with only on the pollen grains of some angiosperms. In general characters the sporomorph seems similar to juglandoid grains.

#### Standard-Vacuum Oil Company, Calcutta

Emphasis during 1955 was given to improvement of laboratory techniques, and by the end of the year about sixty samples per day were being processed. Palaeontological investigations included the examination of fossil foraminifera, spores, pollen, and hystrichospherids in rock samples from the Cretaceous — Tertiary sequence of eastern India.

Several important palaeontological horizons were established. These horizons have widespread distribution and are proving to be a great aid in field geologic mapping. Heavy mineral work was discontinued and has been replaced by microlithological examination of washed residues prior to palaeontological study.

#### Lucknow University

K. Mohan and A. K. Chatterji, research students working under the direction of your correspondent, were recently awarded their doctorates by this university. Their theses were entitled, respectively, "Geology of parts of Kathiawar with studies on the Miogypsinidae of western India," and

"Geology of parts of Kathiawar with studies on the foraminifera from this peninsula." After jointly carrying out the detailed mapping of this area and the study of the foraminiferal assemblages from the Miocene beds of Kathiawar, Mohan and Chatterji have divided these beds into three distinct horizons. The two lower horizons are grouped under lower Burdigalian, while the third constitutes the upper Burdigalian. Their main stratigraphic conclusions are as follows:

- 1) Middle Miocene beds of Vindobonian age are not present in western India and Ceylon. Beds bearing *Taberina* (formerly *Orbiculina*) *malabarica* (Carter) are associated with *Tryblionepidina*.
- 2) The lower Burdigalian of western India is characterized by the presence of small *Nephrolepidina* of the *sumatrensis* type, and by the absence of *Eulepidina* and *Tryblionepidina*. The miogypsinids characteristic of this horizon are *Miogypsina* (*Miogypsina*) *irregularis* (Michelotti), *Miogypsina* (*Miogypsina*) *drogeri* Mohan, and *Miogypsina* (*Lepidosemicyclina*) *thecidaeformis* (Rutten).
- 3) *Astrotrillina howchini* (Schlumberger) and *Lepidosemicyclina* both occur in the Burdigalian.
- 4) The Miocene fauna as a whole shows affinity with that of Indonesia.

A. R. Rao and K. P. Vimal are continuing their studies of the Tertiary lignites of India. K. P. Vimal has been awarded the Ph.D. from this university, the title of his thesis being "Studies on Tertiary lignites of India." He has described in detail a large number of spores and pollen from lignite samples from South Arcot, Palana, Warkalli, Cutch and Dandot, and has compared some of them with living as well as fossil forms from India and other countries. *Betula*, *Quercus*, *Salix*, *Fraxinus*, *Tilia*, *Potamogeton* and *Palmae* types of pollen are common in some of these lignites. *Botryococcus braunii*, an oil-bearing alga, has been

observed only in Palana and Cutch lignites. As it has not been possible to compare a large number of the spores and pollen with living or fossil species, no definite floral or climatic conclusions could be deduced. However, the presence of fungal fruit bodies comparable with those of the Microthyriaceae and of pollen grains belonging to *Palmae*, together with the absence of conifer pollen, shows that the climate of these regions at the time of the deposition of these lignites was of a warm humid type.

B. S. Tewari is continuing his work on the smaller and larger foraminifera of the Aquitanian of Cutch. He has recognised species of *Elphidium*, *Triloculina*, *Quinqueloculina*, *Spiroloculina*, *Nonion*, *Rotalia*, *Miogypsina*, *Astrotrillina*, *Lepidocyclina* (*Nephrolepidina*), and *Spiroclypeus*.

S. N. Singh is leaving shortly for the U.S.A. for advanced work on foraminifera. He will be working at Cornell University under the guidance of W. S. Cole. S. B. Bhatia has completed a paper on "Recent foraminifera from shore sands of western India." He has recorded forty-six species and varieties from three beach samples, the great majority of which are characteristic Indo-Pacific forms. The paper is awaiting publication.

#### Mysore University

L. Rama Rao and coworkers are continuing their studies of Cretaceous foraminifera and algae from southern India.

S. R. N. RAO  
Lucknow University,  
Lucknow, India



## NORTH AFRICA



MARCEL REY

### ALGERIA

#### S.N. REPAL

During 1955, the main laboratory of geology of the S.N. REPAL in Oued Smar, near Maison-Carrée, was operating under the direction of J. Magné, with the following staff: Two laboratory geologists, C. Tempère and R. Lacassagne, two laboratory assistants, one photographer, one secretary, one illustrator, and seven laboratory helpers. The staff studied 3777 washed residues, 5728 thin sections, and 198 heavy-mineral separations collected from field sections and wells in northern Algeria and the Sahara. The principal methods utilized in the laboratory were studies of microorganisms (foraminifera, ostracodes, pteropods, and charophytes), microfacies, and heavy minerals.

Just as during past years, a great deal of time was spent in routine work. However, some interesting results have been obtained in micropaleontology and microstratigraphy. J. Magné continued his work on the Jurassic, mainly that of the Saharan Atlas and of the Hauts Plateaux Oranais. He also worked on the Cretaceous of the same areas and of the Hodna Mountains and the Zône Sud Tellienne. Magné also carried out a general microstratigraphic study of the Nummulitic of Algeria. Numerous new species of foraminifera of near-reef facies were discovered in the Cretaceous of the Hodna and Saharan Atlas areas (biofacies with *Laffiteina*, *Lockhartia*, *Cuneolina* and *Miliolidae* in the Maestrichtian, biofacies with *Meandropsi-*

*nidae*, *Nummoloculina*, *Dicyclina*, *Cuneolina*, *Miliolidae* and *Lituolidae* in the upper Cenomanian). Some of these new species will be described by Magné in the near future, in collaboration with J. Sigal and M. Reichel. Detailed study of the upper Lutetian of Algeria has made it possible to distinguish several new and characteristic species of Ostracoda and foraminifera. The Ostracoda will be described by V. Apostolescu and J. Magné.

C. Tempère has investigated the microfacies of the Cretaceous of the Mzab area (Sahara) and their paleogeographic distribution. He has also continued his detailed studies of microfacies and microfauna of the Saharan Paleozoic. His principal work in this field was a complete revision of the Silurian-Devonian sequence. Tempère also made a study of the heavy minerals of several Tertiary sections in northern Algeria.

R. Lacassagne has continued his inventory of the microfacies of the Algerian Cretaceous, and has constructed a good stratigraphic scale with those of the upper part. He has also studied the geographic distribution in Algeria of the association of *Meandropsinidae* characterizing the upper Cenomanian in near-reef facies, noting its lateral equivalence with beds bearing members of the *Ophthalmidiidae*. This study will be published together with the description of the new species. In addition, Lacassagne has studied the geographic distribution of an interesting pelagic horizon with abundant specimens of *Fissurina*, which he discovered last year in the lower Turonian, and of another horizon, characterized by *Diplopora*, in the upper part of the Cenomanian. He also carried out a study of the wells of Djebel Foua, south of the Constantine area. He left S.N. REPAL in December and transferred to the C.F.P. (Compagnie Française des Pétroles) in Paris. A new laboratory geologist, Miss S. Chastanier, has replaced him.

At the S.N. REPAL field laboratory in Oued Djenan, near Sidi Aïssa, routine work has continued under the direc-

tion of Mr. Balducchi, who has replaced Mr. Grégoire.

#### C.F.P. (A.)

The C.F.P. (A.) laboratory has been carrying on its work in the sedimentary areas of the eastern Sahara, under the supervision of Mr. Cuvillier. Mr. Fediaevsky is now assisting Mr. Sacal in Algiers, since Mr. Nouet left in February, 1955, to take charge of the Paris laboratory.

Field geological activities were very important during 1955, and the laboratory was swamped with material. Altogether, we prepared and examined about 6000 samples. At the present time, we have a large collection of reference material from the eastern Sahara, between the Saharan Atlas and the Hoggar. Stratigraphic studies are being carried on with this material, and we have established a good microstratigraphic scale with our usual methods, which are based principally on the study of thin sections.

Our Company now has two other laboratories, the one in Paris under the direction of Mr. Nouet, and another in Bordeaux, under the direction of Mr. Dufaure.

#### University of Algiers

In the laboratory of general geology, Mme. G. Glaçon has been carrying on her work on the Recent foraminifera of the Gulf of Gabès, Tunisia, and on the Eocene of the Guergour area, northwest of Sétif. In the laboratory of applied geology, Miss D. Noël and Miss C. Bernard are working under the direction of Professor G. Lucas. Miss Noël has been continuing her study of the Jurassic coccolithophorids of Algeria. Miss Bernard has been working on the Radiolaria of the upper Albian, Vraconian, and Cenomanian discovered by J. Magné and J. Sigal.

#### Service de la Colonisation et de l'Hydraulique (S.C.H.)

Miss J. Thibault has been continuing her work on well and field samples collected by the geologists of the Survey.

## TUNISIA

The SEREPT has now completed its work on southern Tunisia. Mr. Clintz-boeckel has done a small amount of work on the pelagic microfaunas of the Upper Cretaceous, but has been principally interested in some new problems involving the near-reef and littoral facies of the Jurassic and Cretaceous. He has also begun a study of the Paleozoic, in which the Upper Permian is outcropping and the middle and lower parts have been drilled. Mr. Rabate arrived during January to spend some time on a specialized study of the fusulinids.

In the C.P.D.T. laboratory, Mr. T'Hart has been studying microfaunas from numerous samples from a stratigraphic section in western Tunisia (the Kef). The distribution of the species has been studied in detail, particularly that of the species of *Globotruncana*. Mr. T'Hart returned to The Hague in the early part of January, 1956. Mr. Ford has been occupied principally in routine work, particularly on well samples from the Sahel.

## MOROCCO

### Société Cherifienne des Pétroles

During 1955, the activities of the stratigraphic laboratory in Petitjean consisted of studies of the sedimentary petrography and microfaunas of well and field samples from the Petitjean and Moyenne Moulouya areas. About 5520 thin sections and 1900 washed residues were studied. Ecologic studies of foraminifera, carried out for the purpose of understanding the conditions of sedimentation of the lower Miocene clays, have been temporarily discontinued. The systematic mounting of photologs of microfacies of wells has made it possible to resolve some problems involving particularly difficult correlations, and to determine the principal characteristics of sedimentation in the Prerif Jurassic basin. The study of the Domerian and lower Lias is now finished. The extension of this work to the upper Lias and Dogger is expected in 1956.

The study of the microfacies of the "Région préfaine" and "Moyenne

Moulouya" area, which for five years has constituted the principal activity of the laboratory, has finally led to the publication of a book: Rey, M., and Nouet, G., *Les microfaciès de la région préfaine et de la Moyenne Moulouya (Maroc Septentrional)*. Leiden, Netherlands: E. J. Brill (in press). This publication represents a synthesis of our knowledge in this field. The book, illustrated with about two hundred photographs of microfacies, will be published in both French and English in the "International Sedimentary Petrographical Series" edited by Professor J. Cuvillier (Paris) and Dr. H. M. E. Schürmann (The Hague).

Mr. M. Dardenne has left his position in the Petitjean laboratory and has gone to Madagascar (C.P.M.) He has been replaced by Mr. J. Duchêne, formerly a subsurface geologist.

MARCEL REY

Société Cherifienne des Pétroles  
Petitjean, French Morocco

## UNITED STATES — WEST COAST



HANS E. THALMANN

### Scripps Institution of Oceanography, La Jolla, California

Fred B Phleger and Frances L. Parker report the following activity at the Scripps Institution: Phleger is at present working on seasonal studies of living populations in lagoons and on the continental shelf of central Texas, and on ecological studies of foraminiferal assemblages in the Scammons

Lagoon of Baja California. Frances Parker is investigating the foraminiferal content and ecologic significance of deep-sea cores taken by the Swedish Deep-Sea Expedition in the eastern Mediterranean region. John Bradshaw is experimenting with cultures of Recent foraminifera and is studying planktonic foraminifera from the Pacific Ocean. Robert Lankford is engaged in examining the seasonal behavior of foraminifera in the delta region of the Mississippi River, and T. Uchio is studying the distribution of living and dead foraminiferal populations in the San Diego area.

Taro Kanaya is finishing his studies of fossil algae from California at Scripps Institution before taking over a teaching position in June at Tohoku University in Sendai, Japan. M. N. Bramlette is continuing his research on cocolithophorids and discoasterids. Dean Milow, who is now teaching at San Diego State College, is working on his Ph.D thesis (Stanford), on the foraminiferal sequences from Upper Cretaceous to Eocene in the San Diego area.

### University of Southern California, Los Angeles, California

Orville L. Bandy informs us that he has several advanced graduate students in micropaleontology, whose research topics range from Permian fusulines to problems of Recent foraminiferal ecology. Robert Arnal is completing his doctor's dissertation, on the foraminifera and sediments of the Salton Sea.

S. E. Nakkady (Alexandria, Egypt) is at present completing his research on the boundary between the Cretaceous and Tertiary in Egypt, and will shortly go to Stanford University to continue his work there. Heinrich Hiltermann (Hannover) spent several days last fall with Bandy, and gave a lecture on his and his colleagues' work on the German Cretaceous.

### Bakersfield area

The paleontologists and stratigraphers in the Bakersfield region have organized monthly meetings at which

lectures on the whole field of paleontology are given by invited speakers. During 1955, Robert Kleinpell (Berkeley), Orville L. Bandy (Los Angeles), Fred B Phleger (La Jolla), Hans E. Thalmann, and Klaus Küpper (Stanford) lectured on various topics of foraminiferal research and applied foraminiferology.

#### Stanford University, Stanford, California

J. J. Graham has decided to spend a second year at the University of the Philippines, Quezon City, organizing and training Philippine students in micropaleontology. He will return to Stanford next fall. Hans E. Thalmann delivered his presidential address at the New York meeting of the S.E.P.M. last spring, and visited Alfred and Helen Loeblich and Ruth Todd at the U. S. National Museum in Washington, D. C. He spent the summer months in Mexico City as consulting paleontologist to Petróleos Mexicanos, and will be there again this coming summer, helping to organize and carry out the excursion to the type localities of the Tertiary formations in the Tampico—Poza Rica area during the Twentieth International Geological Congress, to be held in Mexico City. For the first time, there will be a section devoted exclusively to micropaleontology in connection with an International Geological Congress. Thalmann has recently tendered his resignation as editor of the Cushman Foundation's "Contributions" in order to devote more time to research work and to finishing his "Index to Genera and Species of Foraminifera 1890-1950", as well as the index of genera and species published in the first twenty volumes of the *Journal of Paleontology*.

Roger Y. Anderson is engaged in work on his thesis, on fossil spores and pollen. Max Furrer, of Switzerland, is doing research work on Iranian foraminifera, having spent the past

five years as a micropaleontologist with the Iranian Oil Company in Teheran. George L. Harrington, a research associate, is daily augmenting his large collection of Recent foraminifera from all over the world, and this year intends to go to Europe on an extensive collecting trip. Klaus Küpper left Stanford last summer and is now working for the Bataafsche Petroleum Maatschappij in The Hague.

Visitors to the Stanford University Division of Micropaleontology during the past year were: Y. Nagappa, of Digboi, Assam; Heinrich Hiltermann, of Hannover, Germany, who worked on arenaceous foraminifera and gave several lectures on Carpathian and North German micropaleontology; and Eugenia Montanaro-Gallitelli, of Modena, Italy. Max Furrer plans to stay on as a research associate until the end of this academic year, and S. E. Nakkady is expected for a longer stay beginning in March.

Weldon W. Rau, of the U. S. Geological Survey at Menlo Park, has just finished a manuscript on Tertiary foraminifera from the state of Washington, and Merle C. Israelsky is engaged in a thorough study (zonation and paleoecology) of the Tertiary sequence on an island off the California coast. Both are active participants in the weekly seminar in micropaleontology held at Stanford.

#### San Francisco region

York Mandra, who is writing his Ph.D. thesis at Stanford, is working on the systematics and paleoecology of California Eocene Silicoflagellata, and reports that G. D. Hanna has finished the chapter on Silicoflagellata for the Treatise of Invertebrate Paleontology. A. S. Campbell is studying the Radiolaria of the "Franciscan series" of California, and would appreciate it if thin sections from this formation were submitted to him for study.

#### University of California, Berkeley, California

Robert M. Kleinpell has written a note on the correlation of the Tertiary sediments of the Philippines and the applicability of the Dutch "letter classification," which is expected to appear shortly in the *Bulletin of the A.A.P.G.* Kleinpell is busy supervising the theses of quite a number of his students: H. P. Smith, on foraminifera from the Wagonwheel formation, Devils Den district, California; Robert Blaiddell, on Upper Eocene foraminifera from north of Ojai, California; Henry T. Herlyn, on foraminifera from the type Anita shale, California; William R. Weaver, on foraminifera from Cozy Dell, Santa Ines Mountains, California; Frank R. Sullivan, on the stratigraphic distribution of foraminifera in the San Lorenzo formation; Paul Wesendonk, on Eocene and Oligocene foraminifera from the Santa Cruz Mountains; William Fairchild, on foraminifera from the Vaqueros formation, Santa Cruz Mountains; William Wardle, on foraminifera from the Lucia shale, Santa Lucia Mountains; Gene Molander, on foraminifera from the Cozy Dell shale, Nojoqui area, Santa Barbara County; Donald Weaver, on Middle Eocene foraminifera from the Nojoqui Park area; Knoxie DeLise, on foraminifera from the San Emigdio formation of the southern San Joaquin Valley; and Dora Gutierrez, on foraminifera from the Upper Eocene, Oligocene and Miocene of Peru. Together with Hubert G. Schenck (Mollusca), Kleinpell is describing the foraminifera for a monograph on the Gaviota formation. Zach M. Arnold is engaged in a study of living populations of miliolids, and Jane Gray is working on pollen from a Middle Miocene formation.

HANS E. THALMANN  
Stanford, California

